

# WORK MACHINE MANAGEMENT SYSTEM

## BACKGROUND OF THE INVENTION

### 5 1. Field of the Invention

This invention relates to a work machine management system and scheduled work planning system, and particularly to systems suitable for application in cases where a plurality of construction machines is jointly engaged in work such as road construction work.

### 10 2. Description of the Related Art

When large scale public works construction such as road construction is carried out, a plural number of construction machines of a plurality of types, such as bulldozers, hydraulic shovels, road rollers, graders, and dump trucks, performs work simultaneously. In such cases, it is rare that all of the  
15 construction machines are made unmanned construction machines, and, in actuality, the work is carried on in a coordinated manner using manned construction machines having operators on board. Ordinarily, in order to facilitate labor management and the like, operators are required to produce daily work reports in which the operators' own work times are recorded.

20 When construction work is started, a construction work process management chart (hereinafter called a Gantt chart) is produced, based on the requirements of the client, and construction work is carried out according to that Gantt chart. As used here, a Gantt chart is a scheduled work plan that divides the construction work into several work processes, and notes the types  
25 and numbers of construction machines required for each work process, as well as the daily schedule required for each work process. As the construction work is carried out, work progress is noted on the Gantt chart, and that is compared against the initial schedule plan.

However, in the strict sense, it is rare that construction work is completed according to the initial schedule plan indicated in the Gantt chart. That is, in actuality, troubles arise such as unforeseeable troubles in the construction machines, and downtime in excess of initially scheduled maintenance, whereupon construction progress is delayed by the amount of time required to correct such troubles and perform such maintenance.

Enormous labor is usually expended at the construction site in order to make up for such lost time.

Accordingly, an indispensable entity at the construction site is a service supervisor (machine maintenance supervisor) whose role is to quickly discover the cause of every trouble, quickly identify the part or area of the machine requiring maintenance, arrange for the delivery of necessary parts, and arrange for the dispatch of service personnel to perform repairs.

The service supervisor checks the condition of the construction machines and decides when to schedule maintenance. The service supervisor also specifies the trouble area involved in a construction machine malfunction or the like, and the nature of the trouble, and decides whether or not corrective action needs to be taken immediately. As a result of such decisions, when parts must be replaced, the service supervisor verifies whether such replacement parts are available at the parts depot (parts warehouse), and arranges for those replacement parts to be sent. The service supervisor also arranges for service personnel to be called from a service point (service company) for the purpose of correcting the trouble and performing maintenance. When the trouble has been corrected and maintenance completed, the service supervisor notifies operators that the situation has been returned to normal.

In order to cause a plurality of construction machines to perform work efficiently, an indispensable entity at the construction site is a general site

foreman (construction manager) whose role is to give work directions to all of the construction machines on the site and manage how the construction work is carried on.

The general site foreman determines what work is to be performed by each construction machine, according to the Gantt chart, and, while the construction work is being carried on, checks on the progress of the work being done by each construction machine (operator). The general site foreman also designates the operating range for each construction machine. The general site foreman also manages the site so that the construction work will be completed according to the schedule plan, while making decisions on whether or not to continue the construction work whenever an anomalous situation arises, such as a trouble requiring resolution, maintenance, adverse weather, changes in the requirements of the client, or the uncovering of historic remains or the like.

In addition to the general site foreman, an indispensable entity at the construction site is a general site manager whose role is to make arrangements to obtain the construction machines required for the work and manage the overall progress of the construction work.

The general site manager produces the Gantt chart, selects the types and numbers of construction machines required for each work process, rents the selected construction machines from a rental (lease) company or purchases them from a manufacturer, and manages the deployment of vehicles. The general site manager also checks on the progress of the work done by each construction machine, compares the actual work progress achieved against the initial scheduled work plan indicated in the Gantt chart, and, in cases where work is not progressing according to the initial scheduled work plan, revises the initial scheduled work plan indicated in the Gantt chart. The general site manager also makes decisions on whether or not to bring in additional

construction machines in order to make up for work delays. The general site manager also informs the affected construction machine operators and the general site foreman that such revisions have been made in order that work be performed according to the revised scheduled work plan.

5 Another indispensable entity at the construction site is an office manager (labor manager) whose role is to perform the various kinds of office work associated with carrying out construction work.

The office manager checks the daily work reports produced by the operators and otherwise manages operator work. The office manager also  
10 computes wages to be paid to operators and implements procedures for transferring those wages to the accounts of the operators. Also, in cases such as where a trouble has been corrected by a service person, the office manager implements processing to settle invoices for those expenses and implements procedures for transferring funds to the invoicing parties.

15 Thus, at the construction site, such managers as the service supervisor, general site foreman, general site manager, and office manager are necessary in addition to the operators. It is very difficult for the work done by those managers to be done additionally by the operators themselves and still achieve quality management, and, in actuality, one or a plurality of managers is  
20 required in addition to the operators.

This gives rise to a demand to be able to reduce the number of managers other than operators engaged in substantive work and thereby reduce personnel costs. It is also hoped that it will become possible to conduct management promptly, at a higher level and more accurately than conventionally, without  
25 causing the quality of such management to decline.

Thereupon, inventions have been public knowledge for some time for sending data detected by sensors deployed in construction machines, that is, data such as current position, service meter value, fuel remaining, and engine

r.p.m., by communication devices, to a managing unit, and efficiently managing the construction machines by that managing unit.

In Japanese Patent Application Laid-Open No. H6-330569/1994 (published), for example, an invention is described wherewith a managing unit and construction machines are connected between by communication means so as to facilitate bidirectional communications, whereupon data requests are transmitted from the managing unit and, at the construction machines, data are extracted and sent back to the managing unit. In the publication cited above, moreover, an invention is described wherewith, in cases where a maintenance person is at a location removed some distance from the managing unit, a data request is transmitted using a customer's computer at the place being visited, and data are extracted at the construction machine and sent back to that customer's computer.

Based on that invention, construction machine information can be collected on the display screen either of a computer in the managing unit or of the customer's computer, and the construction machine can be managed.

However, based on the invention described in that publication, the information on the construction machine end cannot be collected on the managing unit end unless a request for data is made from the managing unit to the construction machine. Accordingly, an enormous amount of time is required from the time of the request for data to the construction machine until the sent data are processed and the data required for management are produced.

In cases where there is a plurality of construction machines, moreover, it is necessary to transmit data requests separately to each individual construction machine and to have data sent back to the managing unit from each individual construction machine. Because of this necessity of communicating with the construction machines one by one, the number of radio channels increases, and the costs required for those communications become great.

Also, the managing unit is ordinarily removed from the construction site. For that reason, a manager at the managing unit cannot ascertain the movements of the construction machines in the construction site by viewing them directly. For that reason, it is not possible to send work instructions to the construction machines responsive to changes in the site conditions or to manage the work progress thereof in a proper and accurate manner.

In Japanese Patent Application Laid-Open No. H10-183691/1998 (published), furthermore, is described an invention wherewith connection is made between a monitoring apparatus and one master machine among a plurality of work machines so as to facilitate communications by high-power radio communication equipment, connections are also made between the master machine and the other work machines, which constitute a plurality of slave machines, so as to facilitate communications by low-power radio communication equipment, instructions are sent from the monitoring apparatus to the plurality of slave machines via the master machine, and the plurality of slave machines receiving those instructions sends back operational data to the monitoring apparatus via the master machine.

Based on that invention, the number of high-power radio communication devices can be reduced, and the frequency of communications between the monitoring apparatus and the work machines can be reduced, wherefore communication costs can also be reduced.

Based on the invention described in that publication, however, operational data from the slave machines cannot be collected by the monitoring apparatus unless requests for operational data are made to the plurality of slave machines from the monitoring apparatus. Accordingly, an enormous amount of time is required from the requesting of operational data from the slave machines until the sent operational data are processed and the data required for management are produced.

Also, the monitoring apparatus is usually removed some distance from the construction site. For that reason, the manager of the monitoring apparatus cannot ascertain the movements of the construction machines in the construction site by viewing them directly. For that reason, it is not possible to  
5 send work instructions to the construction machines responsive to changes in the site conditions or to manage the work progress thereof in a proper and accurate manner.

The applicant in this filing has also applied for various patents relating to unmanned dumping systems.

10 More specifically, an invention has been publicly disclosed wherewith, in cases where a plurality of unmanned dump trucks is operated at a wide area mining site or the like, data transmission and reception are performed by wide area radio communications (VHF) between a monitoring station and the plurality of unmanned dump trucks, and data transmission and reception are  
15 performed by local radio communications (SS radio communications) between the plurality of dump trucks.

Based on that invention, management is possible by a monitoring station such that a plurality of unmanned dump trucks can travel safely at a wide area work site.

20 However, because each of the plurality of unmanned dump trucks must carry both communication equipment for wide area radio communications and communication equipment for local radio communications, the cost of communication equipment becomes great.

Also, it is necessary for the monitoring station to engage in wide area  
25 radio communications individually with the plurality of unmanned dump trucks, wherefore the number of radio channels increases, and the costs required for communications become great.

Also, even if the monitoring station is deployed inside the wide area work site, the manager of the monitoring station cannot ascertain the movements of the distantly removed unmanned dump trucks by viewing them directly. For that reason, it is not possible to send work instructions to the unmanned dump trucks responsive to changes in the site conditions or to manage the work progress thereof in a proper and accurate manner.

Thus the following troubles are encountered with conventional construction machine management systems.

1) A minimum of one manager is required at the managing station end, in addition to the operators, whose role is to collect construction machine information and send instructions to the construction machines, wherefore personnel costs become great.

2) Because it is necessary to perform radio communications between the managing station and each of the plurality of construction machines, the number of radio channels increases, whereupon equipment costs and communication costs become great.

3) A manager at the managing station cannot ascertain the movements of the construction machines in the work site by viewing them directly, and therefore cannot send work instructions responsive to changes in the site conditions or manage the work progress thereof in a proper and accurate manner.

## SUMMARY OF THE INVENTION

A first object of the present invention is to resolve those troubles and make provision so that a plurality of construction machines can be properly managed by the operators alone.

As noted earlier, it is rare for construction work to be completed according to the initial scheduled work plan indicated in the Gantt chart. The



progress of the construction work is delayed by the time required for trouble correction and maintenance. For that reason, in cases where construction work could not be carried on according to the daily schedule in the initial scheduled work plan, work must be done to revamp the Gantt chart and revise the  
5 scheduled work plan.

Here, the work of producing and revising a Gantt chart can be done automatically using software.

However, the information required for that production and revision must be obtained with dependence on human intervention and data must be input  
10 manually. Not only so, but the scheduled work plan must be revised every time a situation arises that causes a delay in the daily schedule. Therefore, every time something happens that causes the daily schedule to be delayed, the general site manager must make inquiries to find out from the service personnel how much time will be required for maintenance and the like, and, in cases  
15 where it is necessary to increase the number of construction machines in order to make up for work delays, to find out whether such are currently available from a rental company, and thus acquire the information needed to revise the scheduled work plan.

However, the work of making such inquiries is onerous, and an  
20 enormous amount of time is required before the results of those inquiries are available. For that reason, it has not been possible to perform the work of revising scheduled work plans quickly. When the work of revising the scheduled work plan cannot be done quickly, temporarily suspending the construction work during that time cannot be avoided, construction completion  
25 is delayed, and the work required to make up for the construction work delay increases. In addition to those troubles, when the construction work is carried on without making up for such delays, that will have an effect on other construction work.

The inventors, in view of the actual situation described in the foregoing, established a second object, namely that of making provision so that the work of revising a scheduled work plan can be performed quickly without dependence on human intervention.

5 Now, the work itself both of producing a Gantt chart based on the construction work requirements established by the client side, and of revising the Gantt chart in response to the occurrence of troubles with the construction machines and the like, can be done automatically using software, as noted earlier. More specifically, using such software, after inputting various kinds of  
10 requirement data, such as the client's completion data, budget, and environmental considerations, simulations are performed to determine the types and numbers of construction machines required for each work process, and the number of days required for each work process, and a scheduled work plan is automatically generated.

15 However, because such software generates scheduled work plans by simulation, the discrepancies with actual work progress are often large. Such discrepancies can be made smaller by improving the software, but there is a limit to how far that can be done.

20 When troubles or the like arise, furthermore, it might be possible to generate a scheduled work plan after making revisions by simulations performed by inputting data. However, in those cases also, there is a limit on the degree to which the discrepancy between the revised scheduled work plan so generated and the actual work progress can be diminished.

25 A third object of the present invention, which was devised in view of the actual situation described in the foregoing, is to make provision so that a scheduled work plan can be newly produced or revised so as to minimize discrepancies with actual work progress.

Now, at the time that a scheduled work plan has been produced, even assuming that the types and numbers of construction machines required for the construction work have been clearly determined, it is often difficult to quickly acquire the construction machines required from construction machine rental companies or construction machine manufacturers. That is because, although the rental companies and manufacturers do purchase or produce construction machines after making demand forecasts that are to some degree long-range, they do not purchase or produce construction machines on the basis of forecasts made of individual construction projects.

A fourth object of the present invention, which was devised with the actual situation described in the foregoing in view, is to make provision so that rental companies or manufacturers can purchase or produce construction machines after forecasting individual construction projects, and so that, at the point in time when a scheduled work plan has been produced, the required construction machines can be quickly secured from the rental companies or manufacturers.

Now, at construction sites for large scale public works construction work and the like which have an enormous environmental impact on the neighboring residents, in order to promote mutual understanding with the neighboring residents, a white board is set up in the vicinity of the construction site, and information relating to the construction site is noted thereon to widely disclose such information. In that case, a noise-level meter is installed at the construction site, a person in charge of public relations reads the values indicated on the noise-level meter, and noise levels are written by hand on the white board. Or, the person in charge of public relations finds out construction work schedules and what progress has been made from the general site manager or the like, and such schedules and progress are written by hand on the white board.

However, because the writing of such information relating to the construction site is entirely done by hand, information is erroneously displayed due to indolence, misreading, or mishearing, or the display of information is delayed or the like. Thus there has been a trouble in that information relating to a construction site cannot be communicated accurately and in real time to the neighboring residents. The work load on the person in charge of public relations is also great, and there have been demands made to reduce that work load.

A fifth object of the present invention, which was devised with the actual situation described in the foregoing in view, is to make provision so that information relating to the construction site, such as the daily construction schedule and environmental conditions and the like, will be provided to the residents in the vicinity of the construction site accurately and in real time, and so that mutual understanding with the neighboring residents can be better fostered than conventionally, and also to lighten the work load on the person in charge of public relations who has the job of communicating information relating to the construction site to the neighboring residents.

Now, the general site foreman and the operators on board the construction machines can monitor for occurrences of anomalous situations, such as a construction machine overturning or being stolen, if within a range wherein they can make visual verification and within the hours of operation, and, when an anomaly does occur, they can contact the proper authorities so that appropriate action is taken.

However, in cases where it is before or after the hours of construction machine operation, or a construction machine has moved to a location which cannot be visually verified, an anomalous situation such as an overturn accident or theft may go overlooked. For that reason, notification to the proper

authorities may be delayed, and it may not be possible to take appropriate action immediately.

Conventionally, moreover, the human intervention of the general site foreman or operators has had to be depended on in monitoring for and  
5 notifying of anomalous situations, and there have been demands made to reduce that work load.

A sixth object of the present invention, which was devised with the actual situation described in the foregoing in view, is to make provision so that the work load involved in monitoring for anomalous situations with  
10 construction machines is reduced and monitoring can be done so that anomalous situations are not overlooked, and so that, when an anomalous situation does occur, prompt notification thereof can be made to the proper authorities.

In order to achieve the first object, a first invention is a work machine  
15 management system for work machines that perform prescribed work by the operation of a plurality of work machines, wherein

the plurality of work machines is connected by first communication means so as to make reciprocal communications possible;

one or a plurality of leader work machines out of the plurality of work  
20 machines, and a server apparatus are connected by second communication means so as to make reciprocal communications possible;

work machine information detection means for detecting work machine information are provided in each of the plurality of work machines;

a database for storing data for managing the plurality of work machines,  
25 and management information production means for producing management information based on the work machine information and on data stored in the database, are provided at the server apparatus end;

work machine information is detected by the work machine information detection means provided in the plurality of work machines, in conjunction with the work progress of the plurality of work machines; the work machine information so detected is transmitted to the leader work machine or machines  
5 by the first communication means;

the leader work machine or machines transmit the transmitted work machine information to the server apparatus by the second communication means;

the server apparatus produces management information based on the  
10 transmitted work machine information and on data stored in the database, and transmits the management information so produced to the leader work machine or machines by the second communication means; and

the leader work machine or machines manage the plurality of work machines based on the transmitted management information.

15 Based on the first invention, a plurality of work machines 31 to 35 is connected by first communication means 6 so as to make reciprocal communications possible, as diagrammed in Fig. 4.

Of the plurality of work machines 31 to 35, one or a plurality of leader work machines 31 and a server apparatus 11 are connected by second  
20 communication means 5 so as to make reciprocal communications possible.

Work machine information detection means for detecting work machine information are provided in each of the plurality of work machines 31 to 35.

On the server apparatus 11 end, as diagrammed in Fig. 1, a database 100 for storing data for managing the plurality of work machines 31 to 35, and  
25 management information production means 13 for producing management information based on the work machine information and data stored in the database 100, are provided.

Work machine information is detected by the work machine information detection means provided in the plurality of work machines 31 to 35, in conjunction with the work progress of the plurality of work machines 31 to 35, and that detected work machine information is transmitted to the leader work machine 31 by the first communication means 6.

The leader work machine 31 transmits the transmitted work machine information to the server apparatus 11 by the second communication means 5.

The server apparatus 11 produces management information based on the transmitted work machine information and data stored in the database 100, and transmits that produced management information to the leader work machine 31 by the second communication means 5.

The leader work machine 31 manages the plurality of work machines 31 to 35 based on the transmitted management information.

Based on the first invention as described above, management information is automatically produced by the server apparatus 11 based on the work machine information of the plurality of work machines 31 to 35 and data stored in the database 100, that produced management information is transmitted to the leader work machine 31, and the operator of the leader work machine 31 can manage the plurality of work machines 31 to 35 based on that transmitted management information.

For that reason, the plurality of work machines 31 to 35 can be managed by the operator of the leader work machine 31 alone. That is, there is no necessity, as conventionally, for a minimum of one manager, other than the operators, at the management station end, to collect construction machine information and issue directions to the construction machines. Hence personnel costs can be reduced.

Furthermore, data communications are only conducted between the leader work machine 31 and the server apparatus 11. That is, there is no need,

as conventionally, to conduct radio communications between the managing station and each of the plurality of construction machines. Thus the number of radio channels can be reduced, and equipment costs and communication costs can be reduced.

5 Also, the operator of the leader work machine 31 can issue work directions to the plurality of work machines 31 to 35 while directly viewing the plurality of work machines 31 to 35 based on the management information, and can manage the progress of the plurality of work machines 31 to 35. In other words, the situation will not arise where the movements of construction machines within the work site cannot be ascertained by direct viewing in cases 10 where management is being performed by a managing station removed some distance from the work site, as conventionally. For that reason, the management of work instructions and work progress can be done properly in response to changes in the site conditions.

15 Based on the first invention, as described in the foregoing, a plurality of construction machines can be managed properly by only an operator.

A second invention is according to the first invention, wherein management information transmitted from the server apparatus to the leader work machine is displayed on a display device provided in the leader work 20 machine.

A third invention is according to the first invention, wherein the prescribed work consists of a plurality of work processes; and the leader work machine is determined for each of those work processes.

25 A fourth invention is according to the first invention, wherein the management information produced by the server apparatus and transmitted to the leader work machine is information relating to maintenance that should be performed on any of the plurality of work machines.



A fifth invention is according to the first invention, wherein the management information produced by the server apparatus and transmitted to the leader work machine is information relating to a trouble that has occurred in any of the plurality of work machines.

5 In order to achieve the second object, a sixth invention is a work machine management system for work machines that perform prescribed work by the operation of a plurality of work machines in accordance with a scheduled work plan, wherein

the plurality of work machines is connected by first communication means so as to make reciprocal communications possible;

one or a plurality of leader work machines out of the plurality of work machines, and a server apparatus are connected by second communication means so as to make reciprocal communications possible;

work machine information detection means for detecting work machine information are provided in each of the plurality of work machines;

a database for storing data for managing the plurality of work machines, and scheduled work plan production means for producing a scheduled work plan based on the work machine information and on data stored in the database, are provided at the server apparatus end;

work machine information is detected by the work machine information detection means provided in the plurality of work machines, in conjunction with the work progress of the plurality of work machines; the work machine information so detected is transmitted to the leader work machine or machines by the first communication means;

the leader work machine or machines transmit the transmitted work machine information to the server apparatus by the second communication means;

the server apparatus produces a scheduled work plan, based on the transmitted work machine information and on data stored in the database, and transmits the scheduled work plan so produced to the leader work machine or machines by the second communication means; and

5 the leader work machine or machines manage the plurality of work machines based on the transmitted scheduled work plan.

Based on the sixth invention, a plurality of work machines 31 to 35 is connected by first communication means 6 so as to make reciprocal communications possible, as diagrammed in Fig. 4.

10 Of the plurality of work machines 31 to 35, one or a plurality of leader work machines 31 and a server apparatus 11 are connected by second communication means 5 so as to make reciprocal communications possible.

Work machine information detection means for detecting work machine information are provided in each of the plurality of work machines 31 to 35.

15 On the server apparatus 11 end, as diagrammed in Fig. 1, a database 100 for storing data for managing the plurality of work machines 31 to 35, and scheduled work plan production means 13 for producing scheduled work plans based on the work machine information and data stored in the database 100, are provided.

20 Work machine information is detected by the work machine information detection means provided in the plurality of work machines 31 to 35, in conjunction with the work progress of the plurality of work machines 31 to 35, and that detected work machine information is transmitted to the leader work machine 31 by the first communication means 6.

25 The leader work machine 31 transmits the transmitted work machine information to the server apparatus 11 by the second communication means 5.

The server apparatus 11 produces a scheduled work plan based on the transmitted work machine information and data stored in the database 100, and

transmits that produced scheduled work plan to the leader work machine 31 by the second communication means 5.

The leader work machine 31 manages the plurality of work machines 31 to 35 based on the transmitted scheduled work plan.

5       Based on the sixth invention as described above, a scheduled work plan is automatically produced (revised) by the server apparatus 11 based on the work machine information of the plurality of work machines 31 to 35 and data stored in the database 100, that produced scheduled work plan is transmitted to the leader work machine 31, and the operator of the leader work machine 31  
10       can manage the plurality of work machines 31 to 35 based on that transmitted scheduled work plan.

Therefore, as with the first invention, a plurality of construction machines can be properly managed by operators alone.

Based on the sixth invention, furthermore, in cases where a trouble has  
15       arisen with any of the plurality of work machines 31 to 35, or where the necessity to provide maintenance to any of the plurality of work machines 31 to 35 has arisen, the work of revising the scheduled work plan can be done quickly without dependence on human intervention.

A seventh invention is according to the sixth invention, wherein the  
20       scheduled work plan transmitted from the server apparatus to the leader work machine or machines is displayed on a display device provided in the leader work machine or machines.

An eighth invention is according to the sixth invention, wherein the  
scheduled work plan comprises a plurality of work processes; and the leader  
25       work machine or machines are determined for each of those work processes.

A ninth invention is according to the sixth invention, wherein the server apparatus transmits information relating to maintenance that should be done to any of the plurality of work machines, and a scheduled work plan produced by

revising the current scheduled work plan in conjunction with maintenance, to the leader work machine or machines.

A tenth invention is according to the sixth invention, wherein a terminal apparatus provided on the end where the maintenance on the plurality of work machines is done is also connected to the second communication means; the server apparatus transmits information relating to maintenance that should be done to any of the plurality of work machines, and a scheduled work plan produced by revising the current scheduled work plan in conjunction with maintenance, to the leader work machine or machines; and the leader work machine or machines transmit instructions for performing maintenance, based on information relating to maintenance that was transmitted, to the maintenance terminal apparatus through the second communication means, and manage the plurality of work machines based on the revised scheduled work plan.

An 11th invention is according to the sixth invention, wherein the server apparatus transmits information relating to troubles that have arisen in the plurality of work machines, and a scheduled work plan produced by revising the current scheduled work plan in conjunction with the occurrence of troubles, to the leader work machine or machines.

A 12th invention is according to the sixth invention, wherein a trouble correction terminal apparatus provided on the end where troubles with the plurality of work machines are corrected is also connected to the second communication means; the server apparatus transmits information relating to troubles that have occurred in the plurality of work machines, and a scheduled work plan produced by revising the current scheduled work plan in conjunction with trouble occurrence, to the leader work machine or machines; and the leader work machine or machines transmit instructions for correcting troubles, based on information relating to troubles that was transmitted, to the trouble

correction terminal apparatus by the second communication means, and manage the plurality of work machines in accordance with the revised scheduled work plan.

A 13th invention is according to the sixth invention, wherein the server apparatus stores in memory schedule and performance results data indicating relationship between a scheduled work plan produced in the past and actual work performance results as performed on the basis of that scheduled work plan, and produces a new scheduled work plan based on the schedule and performance results data.

In order to achieve the third object, a 14th invention is a scheduled work plan production apparatus that, in cases where a scheduled work plan is produced according to work request data indicating the particulars of work requested by an ordering party, and work is caused to be done, using a plurality of work machines, based on that produced scheduled work plan, produces the scheduled work plan, wherein

a database for storing schedule and performance results data indicating the relationship between the scheduled work plan produced in the past and actual work performance results as performed on the basis of that scheduled work plan is provided at the server apparatus end;

a terminal apparatus on the ordering party end, the server apparatus, and the plurality of work machines are connected by communication means so as to make reciprocal communications possible;

the work request data are input from the terminal apparatus on the ordering party end;

the server apparatus produces a scheduled work plan based on the input work request data and on the schedule and performance results data stored in the database, transmits that produced scheduled work plan to the plurality of

work machines by the communication means, and updates the schedule and performance results data in the database;

the plurality of work machines perform work based on the transmitted scheduled work plan and transmit the actual work performance results as performed on the basis of that scheduled work plan to the server apparatus by the communication means; and

the server apparatus updates the database with the actual work performance results transmitted.

Based on the 14th invention, a scheduled work plan produced in the past, and schedule and performance results data indicating the relationship between that scheduled work plan produced in the past and the actual work performance results as performed on the basis of that scheduled work plan, are stored in the database 100 on the server apparatus 11 end, as indicated in Fig. 1.

Also, a terminal apparatus 93 on the ordering party end, the server apparatus 11, and the plurality of work machines 31 to 35 are connected by communication means 1 and 3 so as to make reciprocal communications possible.

Work request data are input from the terminal apparatus 93 on the ordering party end.

The server apparatus 11 produces a scheduled work plan based on the input work request data and on the schedule and performance results data stored in the database 100, transmits that produced scheduled work plan to the plurality of work machines 31 to 35 by the communication means 1 and 3, and updates the schedule and performance results data in the database 100.

The plurality of work machines 31 to 35 performs work based on the transmitted scheduled work plan and transmits the actual work performance results as performed on the basis of that scheduled work plan to the server apparatus 11 by the communication means 1 and 3.

The server apparatus 11 updates the database 100 with the actual work performance results transmitted.

Based on the 14th invention, as described above, provision is made so that the schedule and performance results data in the database 100 are updated according to the actual work performance results as performed by the plurality of work machines 31 to 35 on the basis of that scheduled work plan, and so that a new scheduled work plan is produced on the basis of those updated schedule and performance results data, wherefore the discrepancy between the newly produced scheduled work plan and the actual work performance results can be minimized. For that reason, it becomes possible to newly produce or to revise a scheduled work plan so that the discrepancy with the actual work performance results is minimized.

A 15th invention is according to the 14th invention, wherein when revision data for revising a current scheduled work plan are given, the server apparatus revises the current scheduled work plan based on those revision data, the work request data, and the schedule and performance results data stored in the database, and transmits that revised scheduled work plan to the plurality of work machines by the communication means; and the plurality of work machines perform work based on the transmitted scheduled work plan, and transmit the actual work performance results as performed on the basis of that scheduled work plan to the server apparatus by the communication means.

In order to achieve the fourth object, a 16th invention is a scheduled work plan production apparatus that, in cases where a scheduled work plan is produced according to work request data indicating the particulars of work requested by an ordering party, a plurality of work machines is obtained, and work is caused to be done using the plurality of work machines so obtained, based on that produced scheduled work plan, produces the scheduled work plan, wherein

a database for storing schedule and performance results data indicating the relationship between the scheduled work plan produced in the past and actual work performance results as performed on the basis of that scheduled work plan is provided at the server apparatus end;

5 a rental/production end terminal apparatus for renting or producing the work machines is also provided;

a terminal apparatus on the ordering party end, the server apparatus, the plurality of work machines, and the rental/production end terminal apparatus are connected by communication means so as to make reciprocal  
10 communications possible;

the work request data are input from the terminal apparatus on the ordering party end;

the server apparatus produces a scheduled work plan based on the input work request data and on the schedule and performance results data stored in  
15 the database, transmits that produced scheduled work plan to the plurality of work machines and to the rental/production end terminal apparatus by the communication means, and updates the schedule and performance results data in the database;

the plurality of work machines performs work based on the transmitted  
20 scheduled work plan and transmits the actual work performance results as performed on the basis of that scheduled work plan to the server apparatus by the communication means;

the server apparatus updates the database with the actual work performance results transmitted; and

25 the rental/production end terminal apparatus plans rental or production based on the transmitted scheduled work plan.

Based on the 16th invention, a scheduled work plan produced in the past, and schedule and performance results data indicating the relationship between



that scheduled work plan produced in the past and the actual work performance results as performed on the basis of that scheduled work plan, are stored in the database 100 on the server apparatus 11 end, as indicated in Fig. 1.

Also, a terminal apparatus 93 on the ordering party end, the server apparatus 11, the plurality of work machines 31 to 35, and the rental/production end terminal apparatus 81, 91 are connected by communication means 1 and 3 so as to make reciprocal communications possible.

Work request data are input from the terminal apparatus 93 on the ordering party end.

The server apparatus 11 produces a scheduled work plan based on the input work request data and on the schedule and performance results data stored in the database 100, transmits that produced scheduled work plan to the plurality of work machines 31 to 35 and the rental/production end terminal apparatus 81, 91 by the communication means 1 and 3, and updates the schedule and performance results data in the database 100.

The plurality of work machines 31 to 35 performs work based on the transmitted scheduled work plan and transmits the actual work performance results as performed on the basis of that scheduled work plan to the server apparatus 11 by the communication means 1 and 3.

The server apparatus 11 updates the database 100 with the actual work performance results transmitted.

The rental/production end terminal apparatus 81, 91 plans rental or production based on the transmitted scheduled work plan.

Based on the 16th invention, moreover, every time there is a request for work from an ordering party, a scheduled work plan is produced, and work machine rental or production can be planned based on the scheduled work plan so produced. Thus it becomes possible for a rental company or the factory of a

manufacturer to purchase or produce work machines after forecasting individual construction projects. Hence it becomes possible for the construction company or the like that actually does the work to quickly secure, from rental companies and/or manufacturers, the work machines that will be necessary, at the point in time when the scheduled work plan is produced. Not only so, but that scheduled work plan is one that has been produced based on the schedule and performance results data, in like manner as with the 14th invention, and it is of such accuracy that the discrepancy with the actual work performance results will be minimized. For that reason, plans to rent or produce work machines can be made accurately.

In order to achieve the fifth object, a 17th invention is the first invention, wherein an information display for displaying information toward the outside of the work site where the plurality of work machines is operating is provided in one of the plurality of work machines or in a plurality of those work machines; the server apparatus produces information relating to the work site, based on work machine information transmitted and on data stored in the database, and transmits that information relating to the work site so produced to the leader work machine by the second communication means; and the leader work machine displays that information relating to the work site so transmitted on the information display.

The 17th invention is described with reference to Fig. 3.

Based on the 17th invention, an information display 47 for displaying information toward the outside of the work site where the plurality of work machines 31 to 35 is operating is provided in one of the plurality of work machines 31 to 35 or in a plurality of work machines 31. At the server apparatus 11, information relating to the work site (such as a graph of noise values, a graph of toxic substance concentrations, a work schedule, or a graph of performance results) is produced on the basis of work machine information

(such as noise levels, concentrations of toxic substances in exhaust gases, or operating times) that has been transmitted and data stored in the database 100, and that information relating to the work site so produced is transmitted to the leader work machine 31 by the second communication means 5. At the leader  
5 work machine 31, the information relating to the work site so transmitted (such as a graph of noise values, a graph of toxic substance concentrations, a work schedule, or a graph of performance results) is displayed on the information display 47 carried on board that vehicle.

Based on the 17th invention, information relating to the construction site,  
10 such as daily construction schedules and environmental conditions, can be provided accurately and in real time for residents living in the vicinity of the construction site, wherefore mutual understanding with those neighboring residents can be better fostered than conventionally. Also, the work load on the person in charge of public relations who communicates information  
15 relating to the construction site to the neighboring residents is lightened.

The information displayed on the information display 47 is not limited to graphs of noise values, graphs of toxic substance concentrations, work schedules, or graphs of performance results, moreover, but may be other information such as weather forecasts for the area or the like.

20 An 18th invention is according to the 17th invention, wherein the information display is deployed on a work machine other than the leader work machine; and the leader work machine transmits transmitted information relating to the work site to another work machine by the first communication means and causes that information to be displayed on the information display  
25 deployed on that other work machine.

A 19th invention is according to the first invention, wherein an information display for displaying information toward the outside of the work site where the plurality of work machines is operating is installed in the

vicinity of the work site; the server apparatus produces information relating to the work site, based on the work machine information that has been transmitted and on data stored in the database, and transmits that information relating to the work site so produced to the leader work machine by the second communication means; and the leader work machine displays that information relating to the work site so transmitted on the information display.

A 20th invention is according to the 19th invention, wherein the leader work machine causes the transmitted information relating to the work site to be displayed on the information display installed in the periphery of the work site via the first communication means.

A 21st invention is according to the first invention, wherein an information display for displaying information toward the outside of the work site where the plurality of work machines is operating is installed in the periphery of the work site; the server apparatus produces information relating to the work site, based on the work machine information that has been transmitted and on data stored in the database, transmits that information relating to the work site so produced to the information display by the second communication means, and causes that information relating to the work site so transmitted to be displayed on that information display.

A 22nd invention is a work machine management system for work machines that perform prescribed work by the operation of a plurality of work machines inside a work site, comprising:

environmental condition measurement means for measuring environmental conditions in the periphery of a work site, provided in the periphery of the work site;

an information display or displays for displaying information toward the outside of a work site, installed in the periphery of the work site, or, alternatively, provided in one or more of the plurality of work machines;

communication means for connecting said environmental condition measurement means with a server apparatus and connecting said server apparatus with said information display or displays, so as to make reciprocal communication possible; and

5 display information production means, provided at said server apparatus end, for producing environmental condition display information based on measured environmental condition values and on data stored in a data base; wherein

10 the measured environmental condition values measured by the environmental condition measurement means, in conjunction with the work progress of the plurality of work machines, are transmitted to the server apparatus by the communication means; and

15 the server apparatus produces environmental condition display information, based on the measured environmental condition values so transmitted and on data stored in the database, transmits that environmental condition display information so produced to the information display by the communication means, and causes that environmental condition display information so transmitted to be displayed on that information display.

20 In order to achieve the first object, a 23rd invention is the first invention, wherein when data on the performance results for the work performed by the plurality of work machines are stored in the database in the server apparatus for each of the plurality of work machines, and data requesting the production of a work report relating to a specific work machine, from the leader work machine to the server apparatus, are transmitted by the second communication  
25 means, the server apparatus reads out work performance results data corresponding to the specific work machine from the data recorded in the database, produces a work report indicating particulars of work performed in a certain time period by the specific work machine, and transmits the work

report so produced to the leader work machine by the second communication means, and the leader work machine manages the plurality of work machines based on the work report so transmitted.

The 23rd invention is described with reference to Fig. 8.

5       Based on the 23rd invention, performance results data for work performed by the plurality of work machines 31 to 35 are stored in a database 141A in the server apparatus 11 for each of the plurality of work machines. When data (vehicle ID 200a) requesting that a work report (daily work report) for the specific work machine 33 is transmitted through the second  
10       communication means 5 from the leader work machine 31 to the server apparatus 11, the server apparatus 11 reads out work performance results data corresponding to that specific work machine 33 from data stored in the database 141A, and produces a work report (daily work report) indicating the particulars of work performed by that specific work machine 33 in a certain  
15       period of time (1 day). The work report (daily work report) so produced is transmitted to the leader work machine 31 by the second communication means 5. At the leader work machine 31, the plurality of work machines 31 to 35 is managed on the basis of the work report (daily work report) so transmitted.

20       Thus, based on the 23rd invention, the operator of the leader work machine 31 can manage the labor of operators, checking the daily work reports and the like, and can undertake the additional role of an office manager (labor manager) who computes wages to be paid to the operators and performs procedures to transfer those wages to accounts of the operators.

25       A 24th invention is according to the 23rd invention, wherein a terminal apparatus for labor management on the end where labor management is performed for persons on board the plurality of construction machines and the leader work machine are connected by communication means to make

reciprocal communications possible; the leader work machine transmits the daily work report to the terminal apparatus for labor management by the communication means; and the terminal apparatus for labor management performs labor management for those on board the plurality of construction machines.

In order to achieve the sixth object, a 25th invention is the first invention, wherein the work machine information is work condition information indicating the actual work conditions of a work machine; data on the schedule of work to be performed by the plurality of work machines are stored in a database in the server apparatus, for each of the plurality of work machines; and when the work condition information is transmitted from the leader work machine to the server apparatus by the second communication means the server apparatus reads out work schedule data from data stored in the database, compares those work schedule data and the work condition information transmitted, and, when there is a discrepancy, produces anomaly information indicating that an anomaly has occurred in the corresponding work machine, and transmits the anomaly information so produced to the leader work machine by the second communication means; and the leader work machine manages the plurality of work machines based on the transmitted anomaly information.

The 25th invention is described with reference to Fig. 9.

Based on the 25th invention, data on the schedule of work to be performed by the plurality of work machines 31 to 35 are stored in the database 141A in the server apparatus, for each of the plurality of work machines. When the work condition information (operating time period) is transmitted from the leader work machine 31 to the server apparatus 11 by the second communication means 5, at the server apparatus 11, work schedule data are read out from data stored in the database 141A, those work schedule data (work schedule) and the work condition information that has been transmitted

are compared, and, when there is a discrepancy, anomaly information (theft information) indicating that an anomaly has occurred in the corresponding work machine 33 is produced, and that anomaly information (theft information) so produced is transmitted to the leader work machine 31 by the second communication means 5. The leader work machine 31 contacts the proper authorities 92a and so forth and manages the plurality of work machines 31 to 35 based on the transmitted anomaly information (theft information).

Thus, based on the 25th invention, the work load involved in monitoring for anomalous situations (thefts) in construction machines can be reduced, monitoring can be done so that anomalous situations (thefts) are not overlooked, and the proper authorities can be contacted quickly when an anomalous situation (theft) does occur.

A 26th invention is the first invention, wherein the work machine information is position information indicating the actual position of a work machine; operating positions at which the plurality of work machines operates are stored in a database in the server apparatus; and when the position information is transmitted from the leader work machine to the server apparatus by the second communication means the server apparatus reads out operating position data from data stored in the database, compares those operating position data and the position information transmitted, and, when an actual position deviates from an operating position, produces anomaly information indicating that an anomaly has occurred in the corresponding work machine, and transmits the anomaly information so produced to the leader work machine by the second communication means; and the leader work machine manages the plurality of work machines based on the transmitted anomaly information.

The 26th invention is described with reference to Fig. 9.



Based on the 26th invention, operating positions (construction site positions) at which the plurality of work machines 31 to 35 operates are stored in the database 141A in the server apparatus 11. When the position information is transmitted from the leader work machine 31 to the server apparatus 11 by the second communication means 5, at the server apparatus 11, operating position (construction site position) data are read out from data stored in the database 141A, those operating position (construction site position) data and the position information (actual positions) transmitted are compared, and, when an actual position is removed some distance from an operating position (construction site position), anomaly information (theft information) indicating that an anomaly has occurred in the corresponding work machine 33 is produced, and the anomaly information (theft information) so produced is transmitted to the leader work machine 31 by the second communication means 5. The leader work machine 31 contacts the proper authorities 92a and so forth and manages the plurality of work machines 31 to 35 based on the transmitted anomaly information (theft information).

Thus, based on the 26th invention, the work load involved in monitoring for anomalous situations (thefts) in construction machines can be reduced, monitoring can be done so that anomalous situations (thefts) are not overlooked, and the proper authorities can be contacted quickly when an anomalous situation (theft) does occur.

A 27th invention is the first invention, wherein the work machine information is attitude information indicating the actual attitude of a work machine; attitude limit values for the plurality of work machines are stored in a database in the server apparatus; and when the attitude information is transmitted from the leader work machine to the server apparatus by the second communication means: the server apparatus reads out attitude limit value data from data stored in the database, compares those attitude limit value

data and the attitude information transmitted, and, when an actual attitude exceeds an attitude limit value, produces anomaly information indicating that an anomaly has occurred in the corresponding work machine, and transmits the anomaly information so produced to the leader work machine by the second communication means; and the leader work machine manages the plurality of work machines based on the transmitted anomaly information.

The 27th invention is described with reference to Fig. 9.

Based on the 27th invention, attitude limit values (vehicle inclination angle threshold values) for the plurality of work machines 31 to 35 are stored in the database 151 in the server apparatus 11. When the attitude information (vehicle inclination angles) is transmitted from the leader work machine 31 to the server apparatus 11 by the second communication means 5, at the server apparatus 11, attitude limit value (vehicle inclination angle threshold value) data are read out from data stored in the database 151, those attitude limit value data (vehicle inclination angle threshold values) and the attitude information (actual vehicle inclination angles) transmitted are compared, and, when an actual attitude (actual vehicle inclination angle) exceeds an attitude limit value (vehicle inclination angle threshold value), anomaly information (overturn information) indicating that an anomaly has occurred in the corresponding work machine 33 is produced, and the anomaly information (overturn information) so produced is transmitted to the leader work machine 31 by the second communication means 5. The leader work machine 31 contacts the proper authorities 92b and so forth and manages the plurality of work machines 31 to 35 based on the transmitted anomaly information (overturn information).

Thus, based on the 27th invention, the work load involved in monitoring for anomalous situations (overturns) in construction machines can be reduced, monitoring can be done so that anomalous situations (overturns) are not

overlooked, and the proper authorities can be contacted quickly when an anomalous situation (overturn) does occur.

A 28th invention is according to the 25th invention or the 26th invention or the 27th invention, wherein an anomaly handling terminal apparatus  
5 provided on the end where anomaly handling is performed for a construction machine wherein an anomaly has occurred, and the server apparatus are connected by communication means to make reciprocal communications possible; the server apparatus, when anomaly information has been produced by that server apparatus, transmits that anomaly information to the anomaly  
10 handling terminal apparatus through the communication means; and the anomaly handling terminal apparatus performs anomaly handling for the construction machine at which the anomaly occurred, based on the transmitted anomaly information.

A 29th invention is according to the 25th invention or the 26th invention  
15 or the 27th invention, wherein an anomaly handling terminal apparatus provided on the end where anomaly handling is performed for a construction machine wherein an anomaly has occurred, and the leader work machine are connected by communication means to make reciprocal communications possible; the leader work machine transmits the anomaly information to the  
20 anomaly handling terminal apparatus through the communication means; and the anomaly handling terminal apparatus performs anomaly handling for the construction machine at which the anomaly occurred, based on the transmitted anomaly information.

A 30th invention is a work machine management system for work  
25 machines that perform prescribed work by the operation of a plurality of work machines, wherein

the plurality of work machines is connected by first communication means so as to make reciprocal communications possible;

one or a plurality of leader work machines out of the plurality of work machines, and a server apparatus are connected by second communication means so as to make reciprocal communications possible;

work machine information detection means for detecting work machine information are provided in each of the plurality of work machines;

a database for storing data for managing the plurality of work machines, and management information production means for producing management information based on the work machine information and on data stored in the database, are provided at the server apparatus end;

work machine information is detected by the work machine information detection means provided in the plurality of work machines, in conjunction with the work progress of the plurality of work machines; the work machine information so detected is transmitted to the leader work machine or machines by the first communication means;

the leader work machine or machines transmit the transmitted work machine information to the server apparatus by the second communication means;

the server apparatus produces management information based on the transmitted work machine information and on data stored in the database, and transmits the management information so produced to the leader work machine or machines by the second communication means;

the leader work machine or machines manage the plurality of work machines based on the transmitted management information;

judgment means for judging whether communications are possible or impossible by the second communication means between the leader work machine and the server apparatus are provided in the leader work machine; and

when it is judged by the judgment means that communications by the second communication means are impossible, the latest management

information received by the leader work machine via the second communication means and the latest work machine information received by the leader work machine via the first communication means are stored in memory by the leader work machine until it is judged by the judgment means  
5 that communications by the second communication means have become possible.

Thus, based on the 30th invention, in like manner as with the first invention, management information is automatically produced by the server apparatus 11, based on the work machine information for the plurality of work  
10 machines 31 to 35 and on data stored in the database 100, the management information so produced is transmitted to the leader work machine 31 by the second communication means 5, and the operator of the leader work machine 31 can manage the plurality of work machines 31 to 35, based on the transmitted management information.

Now, when communications by the second communication means 5  
15 become impossible, thereafter, work machine information cannot be transmitted from the leader work machine 31 to the server apparatus 11, and management information can no longer be transmitted from the server apparatus 11 to the leader work machine 31, wherefore it becomes impossible  
20 for management information to be obtained by the leader work machine 31.

That being so, it is necessary to make provision so that, when such a communications failure occurs, during the period of time up until communications are reopened, the plurality of work machines 31 to 35 can be managed, and management information can be smoothly obtained at the point  
25 in time when communications are reopened.

Based on the 30th invention, judgment means for judging whether communications are possible or impossible by the second communication

means 5 between the leader work machine 31 and the server apparatus 11 are provided in the leader work machine 31.

Thereupon, when it is judged by the judgment means that communications by the second communication means 5 are impossible, the latest management information received by the leader work machine 31 via the second communication means 5 and the latest work machine information received by the leader work machine 31 via the first communication means 6 are stored in memory by the leader work machine 31 until it is judged by the judgment means that communications by the second communication means 5 have become possible.

For that reason, until communications by the second communication means 5 are reopened, the plurality of work machines 31 to 35 can be managed, based on the latest management information stored and held in memory. Furthermore, when communications by the second communication means 5 have been reopened, management information can be produced by the server apparatus 11 by transmitting the latest work machine information stored and held in memory to the server apparatus 11, whereupon it becomes possible for that management information to be obtained by the leader work machine 31.

A 31st invention is a work machine management system for work machines that perform prescribed work by the operation of a plurality of work machines, wherein

the plurality of work machines is connected by first communication means so as to make reciprocal communications possible;

one or a plurality of leader work machines out of the plurality of work machines, and a server apparatus are connected by second communication means so as to make reciprocal communications possible;

work machine information detection means for detecting work machine information are provided in each of the plurality of work machines;

a database for storing managing data for managing the plurality of work machines, and management information production software for producing management information based on the managing data and the work machine information, is provided at the management system end;

5 the management system, when the leader work machine is determined, transmits managing data stored in the database and the management information production software to the leader work machine by the second communication means;

10 work machine information is detected by the work machine information detection means provided in the plurality of work machines, in conjunction with the work progress of the plurality of work machines; the work machine information so detected is transmitted to the leader work machine by the first communication means;

15 the leader work machine produces management information, based on the work machine information transmitted from the plurality of work machines by the first communication means, and on the managing data and management information production software transmitted from the management system by the second communication means, manages the plurality of work machines, based on the management information so produced, updates the managing data, and transmits the managing data so updated to the management system, by the  
20 second communication means, every time a certain time period elapses; and

the management system updates the content stored in the database using the transmitted managing data.

25 The data communications between the leader work machine 31 and the server apparatus 11, unlike the reciprocal communications 6 among the work machines 31 to 35, are often conducted by using satellite links which involve high communication cost, for such reasons as that they are conducted over long distances.

That being so, it is hoped that a system can be built wherewith the cost of communications between the leader work machine 31 and the server apparatus 11 can be kept low and also wherewith, as with the first invention, data can be managed comprehensively on the server apparatus 11 end.

5       Based on the 31st invention, that is achieved by imparting the functions of a server apparatus to the leader work machine 31.

That is, as diagrammed in Fig. 4, the plurality of work machines 31 to 35 is connected by the first communication means 6 to make reciprocal communications possible.

10       One or a plurality of leader work machines 31, out of the plurality of work machines 31 to 35, and the management system 11 are connected by the second communication means 5 to make reciprocal communications possible.

Work machine information detection means for detecting work machine information are provided in each of the plurality of work machines 31 to 35.

15       A database 100 for storing managing data for managing the plurality of work machines 31 to 35, and management information production software for producing management information based on the managing data and the work machine information, is provided at the management system 11 end, as diagrammed in Fig. 1.

20       Thereupon, when the leader work machine 31 is determined, the management system 11 transmits managing data stored in the database 100 and the management information production software to the leader work machine 31 by the second communication means 5.

25       Work machine information is detected by the work machine information detection means provided in the plurality of work machines 31 to 35, in conjunction with the work progress of the plurality of work machines 31 to 35, and the work machine information so detected is transmitted to the leader work machine 31 by the first communication means 6.



The leader work machine 31 produces management information, based on the work machine information transmitted from the plurality of work machines 31 to 35 by the first communication means 6, and on the managing data and the management information production software transmitted from the management system 11 by the second communication means 5. The leader work machine 31 manages the plurality of work machines 31 to 35, based on the management information so produced. And the leader work machine 31 updates the managing data, and transmits the managing data so updated to the management system 11, by the second communication means 5, every time a certain time period elapses.

The management system 11 updates the content stored in the database 100 using the latest managing data transmitted.

Thus, based on the 31st invention, the communication link 5 of the second communication means is only used when the leader work machine 31 is determined and the content stored in the database 100 is transmitted to the leader work machine 31, and when managing data are transmitted to the management system 11 each time a certain time period elapses. Hence the cost of communicating by the second communication means 5 is dramatically reduced.

Also, the content stored in the database 100 of the management system 11 is always being updated by the latest managing data, and, as with the first invention, data can be managed comprehensively on the management system 11 end.

A 32nd invention is a work machine management system for work machines that perform prescribed work by the operation of a plurality of work machines, wherein

the plurality of work machines is connected by first communication means so as to make reciprocal communications possible;

one or a plurality of leader work machines out of the plurality of work machines are connected by second communication means so as to make reciprocal communications possible;

work machine information detection means for detecting work machine information are provided in each of the plurality of work machines;

a database for storing managing data for managing the plurality of work machines, and management information production software for producing management information based on the managing data and the work machine information, is provided at the management system end;

when the leader work machine is determined, the managing data stored in the database and the management information production software are written to the leader work machine;

work machine information is detected by the work machine information detection means provided in the plurality of work machines, in conjunction with the work progress of the plurality of work machines; the work machine information so detected is transmitted to the leader work machine by the first communication means;

the leader work machine produces management information, based on the work machine information transmitted from the plurality of work machines by the first communication means, and on the managing data and management information production software that were written, manages the plurality of work machines, based on that management information so produced, and updates the managing data; and

the content stored in the database in the management system is updated by writing the updated managing data to the management system.

The data communications between the leader work machine 31 and the server apparatus 11, unlike the reciprocal communications 6 among the work machines 31 to 35, are often conducted by using satellite links which involve

high communication cost, for such reasons as that they are conducted over long distances.

That being so, it is hoped that a system can be built wherewith communications between the leader work machine 31 and the server apparatus 11 are made unnecessary, and also wherewith, as with the first invention, data can be managed comprehensively on the server apparatus 11 end.

Based on the 32nd invention, that is achieved by imparting the functions of a server apparatus to the leader work machine 31.

That is, as diagrammed in Fig. 4, the plurality of work machines 31 to 35 is connected by the first communication means 6 to make reciprocal communications possible.

Work machine information detection means for detecting work machine information are provided in each of the plurality of work machines 31 to 35.

A database 100 for storing managing data for managing the plurality of work machines 31 to 35, and management information production software for producing management information based on the managing data and the work machine information, is provided at the management system 11 end, as diagrammed in Fig. 1.

Thereupon, when the leader work machine 31 is determined, the managing data stored in the database 100 in the management system 11, and the management information production software, with the installation of a portable recording medium such as a memory card, or the like, are written to a memory device in the leader work machine 31.

Work machine information is detected by the work machine information detection means provided in the plurality of work machines 31 to 35, in conjunction with the work progress of the plurality of work machines 31 to 35, and the work machine information so detected is transmitted to the leader work machine 31 by the first communication means 6.

The leader work machine 31 produces management information, based on the work machine information transmitted from the plurality of work machines 31 to 35 by the first communication means 6, and on the managing data and management information production software written to memory as described earlier. The leader work machine 31 manages the plurality of work machines 31 to 35, based on the management information so produced. And the leader work machine 31 updates the managing data.

The latest managing data so updated are written to the database 100 of the management system 11, and the content stored in the database 100 of the management system 11 is overwritten.

Thus, based on the 32nd invention, unlike with the first invention, communications by the second communication means 5 become unnecessary, and communications by the first communication means 6 alone are sufficient, wherefore communication costs are dramatically reduced.

Also, the content stored in the database 100 of the management system 11 is always being updated by the latest managing data, and, as with the first invention, data can be managed comprehensively on the management system 11 end.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of a management system for managing construction machines in an embodiment;

Fig. 2 is a diagram showing the relationship between information collected from various terminal apparatuses such as a terminal device in a leader work machine and services produced by a server apparatus and provided to the leader work machine or the like;

Fig. 3 is a diagram for showing the communications manners diagrammed in Fig. 1 and 2, in greater detail;

Fig. 4 is a diagram of how combinations of a plurality of construction machines change job by job in construction work;

Fig. 5 is a diagram of processing procedures for when an unscheduled maintenance time arrives for a construction machine;

5 Fig. 6 is a diagram of processing procedures for when a failure or other trouble occurs in a construction machine;

10 Fig. 7 is a diagram that represents both processing procedures for cases where a Gantt chart is automatically produced and processing procedures for correcting a Gantt chart when an anomaly has occurred in a construction machine;

Fig. 8 is a diagram representing an embodiment that automatically produces daily work reports for construction machines;

Fig. 9 is a diagram of processing procedures for when a construction machine theft or overturn accident has occurred;

15 Fig. 10 is a diagram of a Gantt chart in an embodiment;

Fig. 11 is a diagram of a Gantt chart in an embodiment;

Fig. 12 is a diagram of a Gantt chart in an embodiment;

Fig. 13 is a diagram showing an example of the display content on a monitor device in a follower machine;

20 Fig. 14 is a diagram showing an example of the display content on a monitor device in a follower machine;

Fig. 15 is a diagram showing an example of the display content on a monitor device in a follower machine;

25 Fig. 16 is a diagram showing an example of the display content on a monitor device in a follower machine;

Figs. 17(a) and 17(b) are diagrams for describing processing to judge whether or not maintenance should be done; and

Fig. 18 is a diagram for describing processing for specifying the location of an anomaly.

## DESCRIPTION OF THE EMBODIMENTS

5        Embodiments of the work machine management system according to the present invention are now described with reference to the drawings. In these embodiments, the work machines are assumed to be such construction machines as hydraulic shovels, bulldozers, road rollers, cranes, graders, and crushers.

10        In Fig. 1 is diagrammed a management system for managing construction machines in an embodiment.

As diagrammed in Fig. 1, a plurality of terminal devices 21, 23, 25, 31a, 51a, 61a, 71a, 48, 58, 68, 78, 49, 59, 69, 79, 81, 91, 93, and 95, and a server apparatus 11, are connected by the internet 1 or a communication satellite 3  
15        such that reciprocal transmitting and receiving is possible. By the internet is meant the global communication network wherein a plurality of LANs (local area networks) are connected by gateways and bridges so that communications can be done reciprocally and freely.

20        The server apparatus 11 is deployed in a service provider company 10 which provides services performed by the management system of this embodiment.

A terminal device 13 is provided inside the service provider company 10. The terminal device 13 has a database 100. As will be described subsequently, a database 100 is provided such that it is dispersed among a plurality of  
25        terminal devices 13. Data are stored therein for managing the construction machines.

The terminal device 81 is deployed in a factory 80 of a manufacturer who makes construction machines.

The server apparatus 11, terminal device 13, and factory terminal device 81 are connected by an intranet 2 such that reciprocal transmitting and receiving are possible. By intranet is meant an internal company communication network built on the basis of internet technology.

5 The server apparatus 11 manages the input and output of data between the internet 1 or the communication satellite 3, on the one hand, and the intranet 2, on the other, processes the data stored in the database 100 inside the terminal device 13, and produces management information necessary for the management of construction machines at the construction site.

10 The terminal device 21 is deployed in a parts depot 20 that is a parts warehouse where construction machine parts are stored.

The terminal device 23 is deployed at a service point 22 which is a service area where such services as maintenance, inspections, and servicing are performed on construction machines. A service company 20' is configured by  
15 the parts depot 20 and the service point 22.

The terminal device 25 is deployed in a weather forecasting company 24 which provides weather forecasts. The terminal device 25 comprises a database 26. The database 26 stores detailed weather information by region.

The terminal device 48 is deployed in a construction company 30A  
20 which performs construction work using a plurality of construction machines.

The terminal device 49 is deployed in an office 30 within the construction site of the construction company 30A. The terminal device 31a is carried on board a construction machine 31 that of the construction machines belonging to the construction company 30A constitutes a leader work machine.

25 By "leader work machine" here is meant, in a situation where construction work is performed by a plurality of construction machines, as described subsequently, a construction machine having on board an operator responsible

for managing a plurality of construction machines. The construction machines managed by the leader work machine are defined as "follower machines."

As diagrammed in Fig. 4, it is assumed here that the construction company 30A has the construction machines 31 to 41 in its possession. A monitor device 300 is carried on board each of the construction machines 31 to 41. Various types of information, as will be described subsequently, are displayed on a display screen 301 of the monitor device 300 (cf. Fig. 5 to 16).

As diagrammed in Fig. 1, the terminal device 58 is deployed in a construction company 50B that performs construction work using a plurality of construction machines. The terminal device 59 is deployed in an office 50 inside the construction site of the construction company 50B. The terminal device 51a is carried on board a construction machine 51, which, of the construction machines belonging to the construction company 50B, constitutes a leader work machine.

Similarly, the terminal device 68 is deployed in a construction company 60C that performs construction work using a plurality of construction machines. The terminal device 69 is deployed in an office 60 inside the construction site of the construction company 60C. The terminal device 61a is carried on board a construction machine 61, which, of the construction machines belonging to the construction company 60C, constitutes a leader work machine.

Similarly, the terminal device 78 is deployed in a construction company 70D that performs construction work using a plurality of construction machines. The terminal device 79 is deployed in an office 70 inside the construction site of the construction company 70D. The terminal device 71a is carried on board a construction machine 71, which, of the construction machines belonging to the construction company 70D, constitutes a leader work machine.



The terminal device 91 is deployed in a leasing or rental company 90 that rents or leases construction machines.

The terminal device 93 is deployed in a government office 92 that is an ordering party (client) which orders construction work that is performed using construction machines.

The terminal device 95 is deployed in an attachment or construction equipment company 94 that manufactures construction equipment or attachments that are mounted on construction machines.

As will be described subsequently, the terminal devices 21, 23, 25, 31a, 51a, 61a, 71a, 49, 59, 69, 79, 81, 91, 93, and 95 can access data stored in the database 100 at the server apparatus 11 end, in accordance with access rights. Embodiment is also possible such that certain data of the data stored in the database 100 are only allowed to be accessed by certain terminals, and access by the other terminals is not permitted. That can be effected by making access conditional on the operation of entering a certain ID number or a certain code number at the terminal device end.

Next, the communications manner diagrammed in Fig. 1 is described in greater detail with reference to Fig. 2 and Fig. 3.

As diagrammed in Fig. 3, reciprocal transmissions and receptions are made by radio communication links 5 via the communication satellite 3 between the terminal device 21 of the parts depot 20, the terminal device 23 of the service point 22, the terminal device 48 of the construction company 30A, the terminal device 58 of the construction company 50B, the terminal device 68 of the construction company 60C, the terminal device 78 of the construction company 70D, the terminal device 49 of the office 30, the terminal device 59 of the office 50, the terminal device 69 of the office 60, the terminal device 79 of the office 70, the terminal device 31a in the leader work machine 31, the terminal device 51a in the leader work machine 51, the terminal device 61a in

the leader work machine 61, the terminal device 71a in the leader work machine 71, the terminal device 81 of the manufacturer head office 80, the terminal device 91 of the lease company 90, the terminal device 93 of the government office 92, the terminal device 95 of the attachment or construction equipment company 94, and the server apparatus 11 of the service provider company 10.

The terminal device 25 of the weather forecasting company 24 is connected to the internet 1 by a hard line. Therefore, reciprocal transmitting and receiving are done between the terminal device 25 of the weather forecasting company 24 and the other terminal devices 21, 23, 25, 31a, 51a, 61a, 71a, 48, 58, 68, 78, 49, 59, 69, 79, 81, 91, 93, and 95 and the server apparatus 11 via the internet 1 and the communication satellite 3.

Fig. 3 exemplifies a case where construction work is being performed by a plurality of construction machines 31 to 35 at a construction site where construction work undertaken by the construction company 30A is being done. Reciprocal transmitting and receiving are conducted between the plurality of construction machines 31 to 35 by radio communication links 6. For the radio communication links 6, a communication scheme is adopted wherewith radio communications are possible over distances traversing the entire area of the construction site and wherewith data can be transmitted and received at high speed. A spread spectrum (SS) radio scheme may be adopted, for example. On board the leader work machine 31, among the plurality of construction machines 31 to 35, a communication terminal for the radio communication links 5 and a communication terminal for the radio communication links 6 are carried. Also carried on board the leader work machine 31 is a monitor device 300 that displays data transmitted thereto from the communication satellite 3 via the radio communication links 5 on the display screen 301. A vehicle-mounted signboard 47 is also carried on board the leader work machine 31.

The signboard 47 is an electric message board for notifying residents in the periphery of the construction site of information relating to the construction site.

Similarly, reciprocal transmitting and receiving are conducted between the plurality of construction machines inside the construction site of the construction company 50B by the radio communication links 6. A stationary type signboard 57 is also deployed in the construction site of the construction company 50B. The signboard 57, in like manner as the signboard 47, provides information relating to the construction site to residents living in the periphery of the construction site.

The situation is similar at the construction sites of the other construction companies 60C and 70D.

The database 100 inside the service provider company 10 is dispersed among the databases 110, 130, 140A, 140B, 140C, 140D, 150, 160, 161, 162, 163, and 164.

The database 110 is a database wherein are stored a program and data necessary for producing a three-dimensional (3D) Gantt chart for each construction project to constitute a construction project-specific optimized 3D Gantt chart production system. A three-dimensional Gantt chart can be produced for each construction project using the program and data stored in that construction project-specific optimized 3D Gantt chart production system 110.

The construction project-specific optimized 3D Gantt chart production system 110 comprises a region specific statistical database group 110A and a machine specific statistical database group 110B. The region specific statistical database group 110A, which is a database wherein are stored statistical data by region, comprises a weather statistics database 111, a 3D

topological map database 112, a soil quality database 113, and a traffic volume statistics database 114.

The weather statistics database 111 stores weather statistics by region. The 3D topological map database 112 stores three-dimensional (3D) topographical maps by region. The soil quality database 113 stores soil quality data by region. And the traffic volume statistics database 114 stores statistics on traffic volumes by region.

The machine specific statistical database group 110B, which is a database wherein are stored statistical data on the construction machines, by type and model, comprises a work capability database 115, a fuel consumption database 116, an environmental impact database 117, a lease fee database 118, and a maintenance cost database 119.

The work capability database 115 stores work capability data by machine type and model. The fuel consumption database 116 stores fuel consumption data by machine type and model. The environmental impact database 117 stores data on the impact on the environment made, by machine type and model. The lease fee database 118 stores lease fee (rental fee) data by machine type and model. And the maintenance cost database 119 stores maintenance costs by machine type and model.

The database 130 is a database wherein are stored a program and data necessary for adding up service related fees that constitute a service related fee totaling system. Fees required for services can be calculated using the data and program stored in this service related fee totaling system 130. The service related fee totaling system 130 comprises a service fee database 131 and a service parts price database 132.

The service fee database 131 stores service fee (wages) data. The service parts price database 132 stores construction machine parts prices.

0997757 10194  
The database 140A, which is a database wherein are stored data related to the construction company 30A, comprises a 3D Gantt chart schedule and performance results database 141A, a service history database 142A, and an internal company 30A parts inventory database 143A.

5 The 3D Gantt chart schedule and performance results database 141A stores 3D Gantt chart schedule and performance results data for construction work performed by the construction company 30A. The service history database 142A stores the history of service provided to construction machines at the construction site of the construction company 30A. And the internal  
10 company 30A parts inventory database 143A stores data on construction machine parts in inventory at the construction company 30A.

The database 140B is a database wherein are stored data related to the construction company 50B. The content stored in the database 140B is similar to that stored in the database 140A. What has been said here applies similarly  
15 to the database 140C of the construction company 60C and the database 140D of the construction company 70D.

The databases 140A, 140B, 140C, and 140D of the construction companies 30A, 50B, 60C, and 70D are collectively called the company specific history database group 140.

20 The database 150 is a database wherein are stored a program and data necessary for judging troubles (anomalies such as failures) generated by construction machines and determining the content of the optimal maintenance to be performed on the construction machines, which program and data constitute a trouble and optimal maintenance judgment system. Using the  
25 program and data stored in this trouble and optimal maintenance judgment system 150, troubles that occur in a construction machine can be judged, and the content of the maintenance that should be performed on the construction machine can be determined. The trouble and optimal maintenance judgment

system 150 comprises a machine specific anomaly judgment database group 150A and a machine specific service judgment database group 150B.

The machine specific anomaly judgment database group 150A, which is a database wherein are stored data for judging anomalies by construction  
5 machine type and model, comprises a standard condition data database 151, an anomalous phenomenon data database 152, a correction time data database 153, and an anomaly location data database 154.

The standard condition data database 151 stores standard condition data that indicate standards for judging anomalies by machine type and model. The  
10 anomalous phenomenon data database 152 stores data on anomalous phenomenon that occur at the construction machines and the seriousness of each anomalous phenomenon in the form of anomalous phenomenon data. The correction time data database 153 stores the times required before anomalies are corrected to normal, by machine type and model, in the form of  
15 repair time data. And the anomaly location data database 154 stores the locations where anomalies occur, by machine type and model, in the form of anomaly location data.

The machine specific service judgment database group 150B, which is a database wherein are stored data for determining the content of maintenance,  
20 by construction machine type and model, comprises a limiting condition data database 156, a maintenance failure fatality level database 157, and a maintenance time required data database 158.

The limiting condition data database 156 stores limiting conditions on whether or not maintenance is required, by machine type and model, in the  
25 form of limiting condition data. The maintenance failure fatality level database 157 stores data indicating the level of fatality that ensues when maintenance is not performed, by machine type and model. And the maintenance time required data database 158 stores times required until

maintenance is finished, by machine type and model, in the form of maintenance time required data.

The machine type and model specific machine number database 160 stores data on vehicle IDs that are symbolic codes which specify each individual construction machine, and the correlation between the construction machine types, models, and machine numbers. The 3D parts shape database 161 stores three-dimensional (3D) shape data on parts configuring the construction machines.

The database 162 is a database wherein are stored a program and data necessary in order to immediately contact the proper locations when an anomalous situation such as a construction machine overturn accident or theft has occurred, which program and data constitute an emergency immediate response system.

The database 163 is a database wherein are stored a program and data necessary in order to forecast demand associated with construction projects expected in the future, which program and data constitute a future expected construction project computation system.

The database 164 is a database wherein are stored a program and data necessary in order to display information relating to construction work on a signboard 47 or 57 at a construction site, which program and data constitute an information display selection system.

In Fig. 2 is diagrammed the relationship between the services provided to the leader work machine 31 produced on the basis of information collected from the terminal devices carried on board the leader work machines such as the terminal device 31a of the leader work machine 31 and on the database 110 at the server apparatus 11, and the like.

In Fig. 2 is diagrammed the construction site of the construction company 30A. A sensor group is provided in each of the construction

machines 31 to 35 for detecting such vehicle conditions (called vehicle condition data) as the hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control input signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k. By lever control input signals f are meant signals indicating the direction and amount of manipulation of a control lever for controlling a working member of a construction machine; the working condition (particulars of work) of a construction machine can be identified according to the lever control input signals f. The construction machines 31 to 41 are each associated with a vehicle ID that specifies the type, model, and number of the vehicle. By stress d, moreover, is meant the value detected by a stress sensor for detecting stresses acting on a working member.

The vehicle ID data and vehicle condition data 200 detected by these multiple construction machines 32 to 35 are transmitted from the leader work machine 31 to the server apparatus 11 via the communication satellite 3, as will be described subsequently. When there has been a request to produce a revised Gantt chart, due to a change in the demands of the client, for example, this revised Gantt chart production request information 600b is transmitted from the leader work machine 31 to the server apparatus 11 via the communication satellite 3.

The government offices 92 comprise a police station 92a, fire fighting (emergency) station 92b, prefectural office 92c, national government 92d, and city/town/village office 92e. In the case where the national government 92d of the government offices 92 is the client, the national government 92d transmits information on construction projects scheduled to be ordered (client demand data) 600a to the server apparatus 11 via the communication satellite 3. The terminal devices 93a, 93b, 93c, 93d, and 93e are deployed, respectively, at the



police station 92a, fire fighting (emergency) station 92b, prefectural office 92c, national government 92d, and city/town/village office 92e.

The construction companies 30A, 50B, 60C, and 70D transmit information on construction projects scheduled to be ordered 202 to the server apparatus 11 via the communication satellite 3.

The lease company 90 comprises a lease company 90a and a rental company 90b. The lease company 90a or rental company 90b transmits information on the construction machines in its possession (machines on hand information) 203 to the server apparatus 11 via the communication satellite 3.

The terminal devices 91a and 91b are deployed in the lease company 90a and the rental company 90b, respectively.

The parts depot 20 of the service company 20' transmits information indicating the results of a search of parts inventories (parts inventory search result information) 204 to the server apparatus 11 via the communication satellite 3.

The service point 22 of the service company 20' transmits information indicating the results of a search for the whereabouts of a service person (service personnel search results information) 205 to the server apparatus 11 via the communication satellite 3.

The manufacturers (manufacturing companies) of the construction machines 80 comprise the manufacturers 80a, 80b, and 80c. Those manufacturers 80a, 80b, and 80c transmit the machine specific statistical database group 110B and/or the machine specific anomaly judgment database 150A to the server apparatus 11 via the communication satellite 3. The terminals 81a, 81b, and 81c are deployed, respectively, in the manufacturers 80a, 80b, and 80c.

The attachment or construction equipment companies 94 comprise a crusher manufacturing company 94a that manufactures crushers, a rock drill

manufacturing company 94b that manufactures rock drills, and a construction material manufacturing company 94c that manufactures construction materials. The crusher manufacturing company 94a, the rock drill manufacturing company 94b, and the construction material manufacturing company 94c  
5 transmit information on the attachments or construction equipment in its own possession (information on attachments or equipment on hand) 178 to the server apparatus 11 via the communication satellite 3. The terminal devices 95a, 95b, and 95c, respectively, are deployed at the crusher manufacturing company 94a, the rock drill manufacturing company 94b, and the construction  
10 material manufacturing company 94c.

The weather forecasting company 24 transmits regional specific detailed weather information 175 stored in the database 26 to the server apparatus 11 via the internet 1 or the communication satellite 3.

At the server apparatus 11, information 165 for a 3D Gantt chart,  
15 whereon are described the optimum processes for construction work yet to be begun, is produced on the basis of the information on construction projects scheduled to be ordered (client demand data) 600a and machine specific statistical database group 110B collected, and on the company specific history database group 140 and construction project specific optimized 3D Gantt chart  
20 production system 110 stored in the database 100. The following information incidental to the production of the 3D Gantt chart information 165 is also produced.

Specifically, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, construction project  
25 cost estimate information 170 indicating a rough estimate of construction project costs is produced. Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, optimum fleet estimate information 171 indicating estimates of the numbers and types of

construction machines needed to complete the construction project is produced.

Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, building equipment demand forecast information 172 indicating the demand for building equipment

5 forecast in conjunction with construction project orders is produced. Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, attachment demand forecast information 173 indicating the demand for attachments forecast in conjunction with

10 construction project orders is produced. Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, parts demand forecast information 176 indicating the demand for parts forecast in conjunction with construction project orders is produced.

Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, service demand forecast  
15 information 177 indicating the demand for services forecast in conjunction with construction project orders is produced. Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, unordered construction project demand forecast information 181 indicating the demand for construction projects not yet ordered is produced.

20 Also, using the 3D Gantt chart information 165 and the future expected construction project computation system 163, machine purchase and replacement demand forecast information 169 indicating the demand for new purchases or replacements of construction machines is produced.

At the server apparatus 11, anomaly handling proposal and revised Gantt  
25 chart proposal information 166 indicating a proposal on how to handle occurrences of anomalies such as changes in client demands, unscheduled maintenance, trouble correction, and changes in weather conditions, and a proposal for a revised 3D Gantt chart (candidate) that revises the initial 3D

Gantt chart is produced, based on the revised Gantt chart production request information 600b, regional specific detailed weather information 175 and vehicle ID data/vehicle condition data 200 that have been collected, and on the company specific history database group 140, construction project specific optimized 3D Gantt chart production system 110, and trouble and optimal maintenance judgment system 150 stored in the database 100.

At the server apparatus 11, parts and service personnel arrival date and time information 167 indicating the date and time of the arrivals of parts and service personnel is produced, based on the parts inventory search result information 204 and service personnel search results information 205 collected.

At the server apparatus 11, accident and theft condition information 168 indicating construction machine overturn accidents and construction machine thefts is produced, based on the vehicle ID data and vehicle condition data 200 collected and on the emergency immediate response system 162 stored in the database 100. The accident and theft condition information 168 comprises accident information 179 and overturn accident information 180.

The anomaly handling proposal and revised Gantt chart proposal information 166 and parts and service personnel arrival date and time information 167 produced by the server apparatus 11 are transmitted to the leader work machine 31 of the construction company 30A via the communication satellite 3.

The machine purchase and replacement demand forecast information 169 produced by the server apparatus 11 is transmitted to the manufacturers 80a, 80b, and 80c.

The parts demand forecast information 176 and service demand forecast information 177 produced by the server apparatus 11 are transmitted respectively to the parts depot 20 and service point 22 of the service company 20' via the communication satellite 3.

The attachment demand forecast information 173 and building equipment demand forecast information 172 produced by the server apparatus 11 are transmitted to the attachment or construction equipment companies 94a, 94b, and 94c.

5 The 3D Gantt chart information 165 and optimum fleet estimate information 171 produced by the server apparatus 11 are transmitted to the construction companies 30A, 50B, 60C, and 70D. The information on construction projects scheduled to be ordered (client demand data) 600a transmitted from the government offices 92 is transmitted to the construction  
10 companies 30A, 50B, 60C, and 70D via the server apparatus 11 and the communication satellite 3.

The accident and theft condition information 168 and unordered construction project demand forecast information 181 produced by the server apparatus 11 are transmitted via the communication satellite 3 to the lease  
15 company 90a and the rental company 90b.

Of the accident and theft condition information 168 produced by the server apparatus 11, the accident information 179 is transmitted to the police station 92a of the government offices 92 via the communication satellite 3. Of the accident and theft condition information 168 produced by the server  
20 apparatus 11, moreover, the overturn accident information 180 is transmitted to the fire fighting (emergency) station 92b of the government offices 92. And the construction project cost estimate information 170 produced by the server apparatus 11 is transmitted to the national government office 92d in the government offices 92 that is the client, via the communication satellite 3.

25 Fig. 4 diagrams how combinations of a plurality of construction machines change job by job in construction work. In Fig. 4 is exemplified a case where road building construction work is being undertaken at the construction site of the construction company 30A.

More specifically, the road building construction work consists of a construction phase 1 wherein a mound of earth is excavated, a construction phase 2 wherein the excavated mound of earth is shaped, and a construction phase 3 wherein the shaped mound of earth is finished to make a road. The road building construction work is completed when construction phase 3 is finished. In construction phase 1, foundation construction work is performed. In construction phase 2, gutter construction work is performed. And in construction phase 3, final paving work is performed.

In construction phase 1, the mound of earth is excavated by bulldozers 31 and 32, a hydraulic shovel 33, and crushers 34 and 35. In construction phase 1, the bulldozer 31 becomes the leader work machine, and the other bulldozer 32, the hydraulic shovel 33, and the crushers 34 and 35 become follower machines. In construction phase 1, data are transmitted and received via a radio communication link 5 between the communication satellite 3 and a terminal device 31a carried on board the leader work machine 31, and the operator on board the leader work machine 31 manages his or her own construction machine 31 and the other follower machines 32, 33, 34, and 35.

In construction phase 2, the mound of earth is shaped by hydraulic shovels 36, 33, 37, and 38, and a crane 39. In construction phase 2, the hydraulic shovel 36 becomes the leader work machine, and the other hydraulic shovels 33, 37, and 38, and the crane 39, become the follower machines. In construction phase 2, data are transmitted and received via a radio communication link 5 between the communication satellite 3 and a terminal device 36a carried on board the leader work machine 36, and the operator on board the leader work machine 36 manages his or her own construction machine 36 and the follower machines 33, 37, 38, and 39.

In construction phase 3, the mound of earth is finished into a road by the hydraulic shovel 33, grader 40, and road roller 41. In construction phase 3, the

hydraulic shovel 33 becomes the leader work machine, and the grader 40 and road roller 41 become the follower machines. In construction phase 3, data are transmitted and received via a radio communication link 5 between the communication satellite 3 and a terminal device 33a carried on board the leader work machine 33, and the operator on board the leader work machine 33 manages his or her own construction machine 33 and the follower machines 40 and 41.

A sensor group is provided in each of the construction machines 31 to 41 for detecting such vehicle conditions (called vehicle condition data) as the hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control input signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k. The construction machines 31 to 41 also have vehicle IDs associated therewith.

These vehicle condition data and vehicle ID data are transmitted as transmission data 200 from the follower machines to the leader work machine via the radio communication links 6. In construction phase 1, for example, the transmission data 200 (vehicle condition data and vehicle ID data) are transmitted from the follower machines 32 to 35 to the leader work machine 31 by the radio communication links 6. The leader work machine 31 then transmits the transmission data 200 (vehicle condition data and vehicle ID data) for the follower machines 32 to 35 and the vehicle condition data and vehicle ID data for that lead machine vehicle itself to the communication satellite 3 via the radio communication link 5.

The operations performed with the embodiment are now described with reference to Fig. 5 to 16 inclusive. In the description which follows, a number of suppositions are made, namely that the national government 92d is the client, that road building construction work is performed at the construction site of the construction company 30A, and that the construction work is being carried on

in construction phase 1 with the construction machine 31 as the leader work machine.

In Fig. 7 is diagrammed an embodiment wherein the operator of the leader work machine 31 can act both as the general site foreman (construction operations manager) and general site manager. The following description is  
5 given with reference to Fig. 2 and Fig. 7.

First, as indicated in Fig. 2, the national government 92d inputs data from the terminal device 93d, and transmits the information on construction projects scheduled to be ordered (client demand data) 600a indicating the  
10 particulars demanded by the client as relating to the road building construction work to the server apparatus 11 of the service provider company 10 via a radio communication link 5, communication satellite 3, and radio communication link 5.

As indicated in Fig. 7, the information on construction projects  
15 scheduled to be ordered (client demand data) 600a is made up of number of lanes and pavement thickness q, budget r, construction phase s, and environmental considerations (exterior appearance, CO<sub>2</sub> emission levels, etc.) t. In the database 100 is stored the information on construction projects scheduled to be ordered (client demand data) 600a. The construction  
20 companies 30A, 50B, 60C, and 70D are authorized to access the information on construction projects scheduled to be ordered (client demand data) 600a stored in the database 100. That being so, when data such as a password are input from the terminal devices 48, 58, 68, and 78 of the construction companies 30A, 50B, 60C, and 70D, and the information on construction  
25 projects scheduled to be ordered 600a is accessed, that information on construction projects scheduled to be ordered 600a is transmitted to the terminal devices 48, 58, 68, and 78 of the construction companies 30A, 50B, 60C, and 70D via a radio communication link 5, communication satellite 3,



and radio communication link 5, stored in memory inside those terminal devices, and displayed on display screens.

At the server apparatus 11, 3D Gantt chart information 165 wherein are described optimal processes (jobs) for a construction project not yet begun is produced, based on the information on construction projects scheduled to be ordered (client demand data) 600a, machine specific statistical database group 110B, company specific history database group 140, and construction project-specific optimized 3D Gantt chart production system 110 stored in the database 100.

Here, every time there is a construction machine design change at the construction machine manufacturers 80a, 80b, and 80c, the data stored in the machine specific statistical database group 110B are transmitted from the manufacturers 80a, 80b, and 80c to the server apparatus 11, and the data stored in the machine specific statistical database group 110B are updated to the latest data.

As indicated in Fig. 7, the construction project-specific optimized 3D Gantt chart production system 110 comprises a similar construction work selection system 706. This similar construction work selection system 706 is a system that selects a Gantt chart, corresponding to past construction work that is similar in terms of the content demanded to the current construction project, from among data stored in 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D that are part of the company specific history database group 140.

Thereupon, the similar construction work selection system 706 retrieves information on past construction work that is similar to the construction work indicated in the information on construction projects scheduled to be ordered (client demand data) 600a from the data stored in the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D (step 701).

Next, processing is performed to revise the selected Gantt chart according to regional characteristics. This is done because, in cases where the region where the current construction work is being performed and the region where the construction work corresponding to the Gantt chart selected was performed differ, there will be differences in soil quality, traffic volume, weather, topography, and so on, in correspondence wherewith the construction period and the like will also differ, whereupon the selected Gantt chart cannot be used as it is.

That being so, the selected Gantt chart is revised (step 702) so that it matches the region where the current construction work is to be performed, using the data stored in the soil quality database 113, traffic volume statistics database 114, weather statistics database 111, and 3D topological map database 112 of the region specific statistical database group 110A.

Next, the Gantt chart is revised according to the construction phase s, budget r, and environmental considerations t that are part of the content demanded by the client. Then a Gantt chart that gives highest priority to the construction phase s (hereinafter called the construction period priority Gantt chart), a Gantt chart that gives highest priority to the budget r (hereinafter called the budget priority Gantt chart), and a Gantt chart that gives highest priority to the environmental considerations t (hereinafter called the environment priority Gantt chart), respectively, are produced as Gantt chart candidates. When the highest priority is given to the construction phase s, the number of construction machines to be deployed becomes large, the budget r becomes large as a tradeoff in completing the construction work in a short time, and environmental considerations t are sacrificed. When the highest priority is given to the budget r, as a tradeoff in performing the construction work with a low budget, the number of construction machines deployed becomes fewer while the construction period becomes long. And when the highest priority is

given to environmental considerations t, the construction period will become longer as compared to the case where priority is given to the construction phase s, but the impact on the environment will be smaller.

Thereupon, the Gantt chart is revised so as to give the highest priority to the construction phase s, using data in the work capability database 115, fuel consumption database 116, environmental impact database 117, maintenance cost database 119, and lease fee database 118 of the machine specific statistical database group 110B. When the highest priority is given to the construction phase s, many construction machine models that exhibit high work capabilities will be deployed at the construction site.

Similarly, the Gantt chart is revised so as to give the highest priority to the budget r, using data in the work capability database 115, fuel consumption database 116, environmental impact database 117, maintenance cost database 119, and lease fee database 118. When the highest priority is given to the budget r, many construction machines of a model exhibiting low maintenance costs, low lease fees, and low fuel consumption will be deployed at the construction site.

Also, similarly, the Gantt chart is revised so as to give the highest priority to environmental considerations t, using data in the work capability database 115, fuel consumption database 116, environmental impact database 117, maintenance cost database 119, and lease fee database 118. When the highest priority is given to the environmental considerations t, the impact on the environment will be low, but many construction machines of models exhibiting low fuel consumption will be deployed at the construction site.

Thus the construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart, respectively, are produced as Gantt chart candidates, and stored as unstarted construction work optimal job (3D Gantt chart) information 165 in the database 100.

In this embodiment, the construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart are exemplified as three Gantt chart candidates, but embodiment is also possible wherewith the number of suitable candidates is further increased, making candidates of a  
5 Gantt chart that gives priority to both the construction phase and the budget, a Gantt chart that gives priority to both the budget and the environment, and a Gantt chart that gives priority to both the construction phase and the environment, or the like.

The following information incidental to the production of the 3D Gantt  
10 chart information 165 is also produced at the server apparatus 11.

Construction project cost estimate information 170 that indicates a rough estimate of costs for the current construction project is produced, using the 3D Gantt chart information 165 and the future expected construction project computation system 163. Also, optimum fleet estimate information 171 that  
15 indicates an estimate of the number and types of construction machines needed to complete the current construction project is produced, using the 3D Gantt chart information 165 and the future expected construction project computation system 163. Also, building equipment demand forecast information 172 indicating the building equipment demand forecast in conjunction with the  
20 ordering of the current construction project is produced, using the 3D Gantt chart information 165 and the future expected construction project computation system 163. Also, attachment demand forecast information 173 indicating the demand for attachments forecast in conjunction with the ordering of the current construction project is produced, using the 3D Gantt chart information 165 and  
25 the future expected construction project computation system 163. Also, parts demand forecast information 176 indicating the demand for parts forecast in conjunction with the ordering of the current construction project is produced, using the 3D Gantt chart information 165 and the future expected construction

project computation system 163. Also, service demand forecast information 177 indicating the demand for services forecast in conjunction with the ordering of the current construction project is produced, using the 3D Gantt chart information 165 and the future expected construction project computation system 163. Also, unordered construction project demand forecast information 181 indicating the demand for construction projects not yet ordered by the clients, including the current construction project wherewith the national government 92d is to be the client, is produced using the 3D Gantt chart information 165 and the future expected construction project computation system 163. Also, machine purchase and replacement demand forecast information 169 indicating the demand for newly purchased and replacement construction machines forecast in conjunction with the ordering of unordered construction projects by the clients, including the current construction project wherewith the national government 92d is to be the client, is produced, using the 3D Gantt chart information 165 and the future expected construction project computation system 163.

All this produced information, namely the construction project cost estimate information 170, the optimum fleet estimate information 171, the building equipment demand forecast information 172, the attachment demand forecast information 173, the service demand forecast information 177, the unordered construction project demand forecast information 181, and the machine purchase and replacement demand forecast information 169, are stored in the database 100.

The construction companies 30A, 50B, 60C, and 70D are authorized to access the unstarted construction work optimal job (3D Gantt chart) information 165 and optimum fleet estimate information 171 stored in the database 100. That being so, when data such as a password are input from one of the terminal devices 48, 58, 68, and 78 of the construction companies 30A,

50B, 60C, and 70D, and the information on construction projects scheduled to be ordered (client demand data) 600a is accessed, in addition to that information on construction projects scheduled to be ordered (client demand data) 600a, the unstarted construction work optimal job (3D Gantt chart) information 165 corresponding to construction projects scheduled to be ordered and the optimum fleet estimate information 171 are transmitted to the terminal devices 48, 58, 68, and 78 of the construction companies 30A, 50B, 60C, and 70D via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory inside those terminal devices, and displayed on display screens.

For that reason, at the construction companies 30A, 50B, 60C, and 70D, it is possible to make judgments easily and quickly as to whether or not a current construction project order should be accepted or not, using the information on construction projects scheduled to be ordered (client demand data) 600a, unstarted construction work optimal job (3D Gantt chart) information 165, and optimum fleet estimate information 171 displayed on the display screens.

Here, the 3D Gantt chart information 165 is produced on the basis of the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D in the database 100. For that reason, when work is performed following a newly produced Gantt chart, discrepancies between the newly produced scheduled work plan and the actual work performance results can be minimized.

Meanwhile, the national government 92d, which is the client, is authorized to access the construction project cost estimate information 170 stored in the database 100. That being so, when data such as a password are input from the terminal device 93d of the national government 92d, and the construction project cost estimate information 170 is accessed, that

construction project cost estimate information 170 is transmitted to the terminal device 93d of the national government 92d via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory inside the terminal device 93d, and displayed on a display screen.

5        Thus the national government 92d is able, easily and quickly, to make a decision as to whether or not the current construction project should be ordered.

10        The manufacturers 80a, 80b, and 80c that are construction machine manufacturing companies are authorized to access the machine purchase and replacement demand forecast information 169 stored in the database 100. That being so, when data such as a password are input from one of the terminal devices 81a, 81b, and 81c of the manufacturers 80a, 80b, and 80c and the machine purchase and replacement demand forecast information 169 is accessed, that machine purchase and replacement demand forecast information 169 is transmitted to the terminal devices 81a, 81b, and 81c of the  
15        manufacturers 80a, 80b, and 80c via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory inside those terminal devices, and displayed on display screens.

20        Thus, every time information on a construction project scheduled for ordering is provided from a client, machine purchase and replacement demand forecast information 169 can be acquired by the manufacturers 80a, 80b, and 80c, and, based thereon, plans for producing construction machines at the factories can be revised, and the construction machines needed for future construction projects can be provided to the market quickly.

25        Thus, at the point in time when 3D Gantt chart information 165 is produced, the construction companies 30A, 50B, 60C, and 70D that undertake the actual work can quickly secure the construction machines needed from the manufacturers 80a, 80b, and 80c. Not only so, but the machine purchase and replacement demand forecast information 169 is produced incidentally to the

3D Gantt chart information 165, and the 3D Gantt chart information 165 itself is produced on the basis of the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D in the database 100, and is very accurate information. Hence the numbers and types of construction machines described in the machine purchase and replacement demand forecast information 169 are extremely accurate. Hence the numbers and types of construction machines produced at the factories of the manufacturers 80a, 80b, and 80c on the basis of the machine purchase and replacement demand forecast information 169 will match future construction project demand with very great accuracy.

Thus the manufacturers 80a, 80b, and 80c can revise their factory production plans quickly, easily, and accurately.

The lease company 90a that leases construction machines and the rental company 90b that rents construction machines are authorized to access the unordered construction project demand forecast information 181 that is stored in the database 100. That being so, when data such as a password are input from a terminal device 91a or 91b of the lease company 90a or rental company 90b, and the unordered construction project demand forecast information 181 accessed, the unordered construction project demand forecast information 181 is transmitted to the terminal devices 91a and 91b of the lease company 90a and rental company 90b via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory inside those terminal devices, and displayed on display screens.

Thus, every time information on a construction project scheduled for ordering is provided from a client, unordered construction project demand forecast information 181 can be acquired by the lease company 90a and the rental company 90b, whereupon, based thereon, the machines necessary for



future lease or rental can be secured so as to be on hand, and the construction machines needed for future construction projects can be provided to the market.

Thus, the construction companies 30A, 50B, 60C, and 70D and the like that perform the actual work, at the point in time when the 3D Gantt chart information 165 is produced, can quickly secure the construction machines that will be needed from the lease company 90a and rental company 90b. Not only so, but unordered construction project demand forecast information 181 is produced incidentally to the 3D Gantt chart information 165, and the 3D Gantt chart information 165 itself is produced on the basis of the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D in the database 100, so it is extremely accurate information. For that reason, the numbers and types of construction machines described in the unordered construction project demand forecast information 181 are very precise. Therefore, the numbers and types of machines secured by the lease company 90a and rental company 90b based on the unordered construction project demand forecast information 181 will match an actual construction project demand with very great accuracy.

Thus the lease company 90a and rental company 90b can secure the machines needed to be on hand for future construction projects quickly, easily, and accurately.

The parts depot 20 that supplies construction machine parts to the market and the service point 22 that performs maintenance and other services on the construction machines are, respectively, authorized to access the parts demand forecast information 176 and the service demand forecast information 177 stored in the database 100. That being so, when data such as a password are input from the terminal device 21 or 23 of the parts depot 20 or the service point 22, and the parts demand forecast information 176 and service demand forecast information 177 are accessed, that parts demand forecast information

176 and service demand forecast information 177 are transmitted respectively to the terminal devices 21 and 23 of the parts depot 20 and the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory inside those terminal devices, and  
5 displayed on display screens.

Thus, at the parts depot 20 and service point 22, respectively, parts demand forecast information 176 and service demand forecast information 177 can be acquired every time information on construction project scheduled to be ordered is presented from a client, and, based thereon, can secure replacement  
10 parts and service personnel for the construction machines that will be necessary for future construction work.

The crusher manufacturing company 94a and rock drill manufacturing company 94b that supply construction machine attachments and the construction material manufacturing company 94c that supplies construction  
15 equipment, respectively, are authorized access to the attachment demand forecast information 173 and building equipment demand forecast information 172 stored in the database 100. That being so, when data such as a password are input from any of the terminal devices 95a, 95b, and 95c of the crusher manufacturing company 94a, rock drill manufacturing company 94b, and  
20 construction material manufacturing company 94c, and the attachment demand forecast information 173 or building equipment demand forecast information 172 is accessed, the attachment demand forecast information 173 or building equipment demand forecast information 172 is transmitted to the terminal devices 95a, 95b, and 95c, respectively, of the crusher manufacturing company  
25 94a and rock drill manufacturing company 94b, and construction material manufacturing company 94c, via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory

inside the terminal device or devices, and displayed on a display screen or screens.

Thus, at the crusher manufacturing company 94a and rock drill manufacturing company 94b, or the construction material manufacturing company 94c, the attachment demand forecast information 173 or the building equipment demand forecast information 172 can be acquired every time information on a construction project scheduled to be ordered is provided from a client, and, based thereon, those companies can supply the construction machine attachments or construction equipment required for future construction work to the market.

The case is presumed where the construction company 30A has accepted the current construction project order.

The construction companies 30A, 50B, 60C, and 70D that perform construction work using construction machines are authorized to access the machines on hand information 203 and information on attachments or equipment on hand 178 stored in the database 100.

That being so, when a password or the like is input from the terminal device 48 of the construction company 30A that has accepted an order for construction work, and the machines on hand information 203 and information on attachments or equipment on hand 178 stored in the database 100 are accessed, the machines on hand information 203 and the information on attachments or equipment on hand 178 are transmitted to the terminal device 48 of the construction company 30A via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory in the terminal device, and displayed on a display screen.

Thus it becomes possible for the construction company 30A to quickly secure the construction machines 31 to 41 required for the ordered construction work from the lease company 90a and the rental company 90b. It also

becomes possible for the construction company 30A to quickly secure the attachments of the construction machines 31 to 41 and construction equipment needed for the ordered construction work from the crusher manufacturing company 94a, rock drill manufacturing company 94b, and construction material manufacturing company 94c.

When the construction machines 31 to 41 needed for the construction work undertaken by the construction company 30A are secured in this manner, 3D Gantt chart information 165 is transmitted from the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5 to the terminal device 31a of the construction machine 31, from among the construction machines 31 to 41, that will be the leader work machine in construction phase 1 of the construction project, and stored in memory in that terminal device 31a.

Thus, as diagrammed in Fig. 7, the 3D Gantt chart information 165 will be displayed on a display screen 301J on the monitor device 300 carried on board the leader work machine 31.

More specifically, the display screen 301J is configured by a display location 320, a select next candidate button 322 for sequentially moving from a candidate 3D Gantt chart currently being displayed in the display location 320 to the next 3D Gantt chart candidate, and a decision button 321 for definitely deciding on the 3D Gantt chart candidate currently being displayed in the display location 320.

Every time the select next candidate button 322 is pressed, the 3D Gantt chart displayed in the display location 320 is sequentially changed from one candidate to the next, that is, from the construction period priority Gantt chart to the budget priority Gantt chart to the environment priority Gantt chart. Thereupon, when the decision button 321 is pressed, the 3D Gantt chart

currently being displayed in the display location 320 (the construction period priority Gantt chart, for example) is determined on.

When the 3D Gantt chart is determined, data indicating the determined 3D Gantt chart (the construction period priority Gantt chart, for example) are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in the 3D Gantt chart schedule and performance results database 141A in the database 100. Thus the "scheduled" data for the 3D Gantt chart schedule and performance results database 141A corresponding to the construction company 30A are updated.

Thus the operator of the leader work machine 31 can also fulfill the role of general site manager in determining Gantt charts.

Fig. 10, 11, and 12 diagram the display screen 301 in a case where the 3D Gantt chart has been determined. These figures, respectively, represent the display screen 301 cut into three segments in the vertical dimension.

As indicated in these figures, a determined 3D Gantt chart is displayed in the display location 320 of the display screen 301. Various buttons 302 to 318, 321, and 322 for altering the content of the display in the display location 320 are arrayed on the display screen 301.

In the 3D Gantt chart represented in Fig. 10, 11, and 12, the construction project is divided into construction phase 1, construction phase 2, and construction phase 3. Therein is written a "schedule" that represents the numbers and types of construction machines required for each construction phase, and the number of days required in each construction phase. A "schedule" is written for each construction machine (by the machine number for each machine deployed), and a "schedule" is also written for all of the construction machines combined. In the 3D Gantt chart are entered the

construction work "performance results," as the construction project advances, which are compared against the initial "schedule."

Another characteristic of the 3D Gantt chart of this embodiment is that it represents the three-dimensional topography of the construction site, for each "schedule" and "performance result," and for each of the construction phases, namely construction phase 1, construction phase 2, and construction phase 3.

More specifically, graphic representations are made therein, respectively, of the three-dimensional topography of the construction site as "scheduled" before work is begun in construction phase 1, the three-dimensional topography of the construction site as "scheduled" after the completion of construction phase 1, the three-dimensional topography of the construction site as "scheduled" before work is begun in construction phase 2, the three-dimensional topography of the construction site as "scheduled" after the completion of construction phase 2, the three-dimensional topography of the construction site as "scheduled" before work is begun in construction phase 3, and the three-dimensional topography of the construction site as "scheduled" after the completion of construction phase 3.

Also, graphic representations are made therein, respectively, of the three-dimensional topography of the construction site indicating the "performance results" before work is begun in construction phase 1, the three-dimensional topography of the construction site indicating the "performance results" after the completion of construction phase 1, the three-dimensional topography of the construction site indicating the "performance results" before work is begun in construction phase 2, the three-dimensional topography of the construction site indicating the "performance results" after the completion of construction phase 2, the three-dimensional topography of the construction site indicating the "performance results" before work is begun in construction phase 3, and the three-dimensional topography of the construction site

indicating the "performance results" after the completion of construction phase 3. Moreover, such indication may be made with actual photographs.

In the 3D Gantt chart information 165, vehicle IDs are given that specify the type, model, and machine number of each of the plurality of construction machines that jointly perform the construction work in each of the construction phases, namely construction phase 1, construction phase 2, and construction phase 3. That is described by referencing Fig. 4 together with Fig. 10, 11, and 12.

In construction phase 1, the construction machines 31 and 32 of type "D" having the machine numbers "31" and "32," the construction machine 33 of type "P" having the machine number "33," and the construction machines 34 and 35 of type "B" having the machine numbers "34" and "35" are deployed and operated.

In construction phase 2, the construction machines 36, 33, and 37 of type "P" having the machine numbers "36," "33," and "37," the construction machine 38 of type "PU" having the machine number "38," and the construction machine 39 of type "L" having the machine number "39" are deployed and operated.

And in construction phase 3, the construction machine 33 of type "P" having the machine number "33," the construction machine 40 of type "G" having the machine number "40," and the construction machine 41 of type "J" having the machine number "41" are deployed and operated.

The 3D Gantt chart information 165 contains position data P that indicate X-Y two-dimensional positions P(X, Y) at the construction site, and follower-machine 3D Gantt chart information 165'. The position data P here are given as longitude and latitude data, for example. By follower-machine 3D Gantt chart information 165', moreover, is meant Gantt charts whereon are described jobs that are to be done by each individual follower machine. The

follower-machine 3D Gantt chart information 165' is transmitted from the terminal device 31a of the leader work machine 31 in construction phase 1 to the terminal devices of the follower machines 32, 33, 34, and 35 via radio communication links 6, stored in memory in the terminal devices, and  
5 displayed on display screens on the monitor devices 300 carried on board the follower machines.

Each of the operators of the follower machines 32, 33, 34, and 35 in construction phase 1 can perform the work that his or her vehicle is to perform by following the follower-machine 3D Gantt chart information 165' displayed  
10 on the display screen of the monitor device 300 in that vehicle.

While construction work is being carried on in construction phase 1, the operator of the leader work machine 31 checks the progress of the work being done by his or her own vehicle 31 and by the follower machines 32 to 35 based on the content displayed on the display screen 301 represented in Fig. 10, 11,  
15 and 12. If the work is delayed, that operator instructs the follower machines 32 to 35 via the radio communication links 6 to make up for that delay. The operator of the leader work machine 31 also informs the follower machines 32 to 35 of operating ranges, via the radio communication links 6, based on the content displayed on the display screen 301 indicated in Fig. 10, 11, and 12.

20 In this manner, the operator of the leader work machine 31 is able to fulfill the role also of a general site foreman who oversees the progress of the work of the plurality of construction machines 31 to 35.

The operator of the leader work machine 31 also checks the progress of the work done by his or her own vehicle 31 and by the follower machines 32 to  
25 35, based on the content displayed on the display screen 301 diagrammed in Fig. 10, 11, and 12, compares the initial "schedule" and "performance results" indicated in the Gantt chart, and, when the work is not progressing according



to the initial schedule, judges whether or not additional construction machines should be deployed to make up the work delay.

The leader work machine 31 is authorized to access the machines on hand information 203 stored in the database 100.

5 That being so, when a password or the like is input from the terminal device 31a of the leader work machine 31, and the machines on hand information 203 stored in the database 100 is accessed, the machines on hand information 203 is transmitted to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and  
10 radio communication link 5, stored in memory inside the terminal device, and displayed on a display screen.

Thereupon, the operator of the leader work machine 31 inputs data from the terminal device 31a containing a request for vehicle deployment, and requests that the construction machines needed to make up the work delay be  
15 deployed. When the type of construction machine is to be changed (or added), a type change button 309, indicated in Fig. 12, is pressed. When the machine number of a construction machine is to be changed (or added), the machine number change button 310 in Fig. 12 is pressed.

Data for requesting vehicle deployment are transmitted to the terminal  
20 devices 91a and/or 91b of the lease company 90a and/or rental company 90b via a radio communication link 5, communication satellite 3, and radio communication link 5. Thus the needed construction machines are quickly deployed at the construction site.

Thus the operator of the leader work machine 31 also fulfills the role of  
25 a general site manager in making arrangements for the deployment of vehicles.

When an anomaly has occurred at the construction site, the Gantt chart is automatically revised by the server apparatus 11, based on anomaly

occurrence data (revised Gantt chart production request information) 600b as will be described below.

By anomaly, here, is meant such an anomalous situation as unscheduled maintenance u performed on a construction machine, a trouble correction v that corrects a failure or other trouble arising in a construction machine, a weather condition change w, and a client demand change x (change in construction period, discovery of historic remains, etc.).

These anomaly occurrence data (revised Gantt chart production request information) 600b may be input directly by the operator of the leader work machine 31 from the terminal device 31a and transmitted to the server apparatus 11, or they may be transmitted to the server apparatus 11 automatically as will be described subsequently with reference to Fig. 5 and Fig. 6. For weather information, detailed weather information for each region can be acquired in the form of regional specific detailed weather information 175 from the database 26 of a weather forecasting company 24 via the internet 1. If the regional specific detailed weather information 175 is used, unlike with the region-specific weather statistics database 111, extremely short-range weather forecasts (that a typhoon will reach land in two or three days hence, for example) can be obtained.

When the anomaly occurrence data 600b are transmitted to the server apparatus 11, as described earlier, in steps 701, 702, and 703, based on the client demand data 600a, a Gantt chart corresponding to a construction project similar to the current construction project is selected (step 701), the selected Gantt chart is revised according to the regional characteristics (step 702), the Gantt chart is further revised according to the construction period s, budget r, and environmental considerations t, and a construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart, respectively, are produced as Gantt chart candidates (step 703).

The construction project-specific optimized 3D Gantt chart production system 110 has an inclement weather daily schedule revision data extraction system 707. This inclement weather daily schedule revision data extraction system 707 is a system that revises the daily schedules written in Gantt charts, according to weather condition changes w, so that the construction work can be completed within the construction period s.

Thereupon, the inclement weather daily schedule revision data extraction system 707 revises the daily schedules written in Gantt charts, in response to weather condition changes w, so that construction work can be completed with the construction period s (step 704).

Next, the similar construction work selection system 706 retrieves information on past construction work for which the Gantt chart was revised according to unscheduled maintenance u, trouble correction v, or client demand change x, from 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D, and revises the Gantt chart, in response to current unscheduled maintenance u, trouble correction v, or client demand change x, so that the construction work is completed within the construction period s (step 705).

Thus data indicating the revised Gantt charts, namely the construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart, are produced as revised 3D Gantt chart data 166b.

As is described subsequently with reference to Fig. 5 and Fig. 6, data indicating a handling proposal for handling an anomalous situation such as maintenance or trouble correction are produced as anomaly occurrence handling data 166a.

The anomaly occurrence handling data 166a and the revised 3D Gantt chart data 166b are transmitted as anomaly handling proposal and revised Gantt chart proposal information 166 from the server apparatus 11 to the

terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in memory in the terminal device 31a.

Thus, as diagrammed in Fig. 7, the anomaly handling proposal and  
5 revised Gantt chart proposal information 166 is displayed on a display screen 301K of the monitor device 300 carried on board the leader work machine 31.

More specifically, the display screen 301K is configured by a display location 320 where the anomaly handling proposal and revised 3D Gantt chart candidate are displayed, a select next candidate button 322 for sequentially  
10 moving from a candidate 3D Gantt chart currently being displayed in the display location 320 to the next 3D Gantt chart candidate, and a decision button 321 for definitely deciding on the 3D Gantt chart candidate currently being displayed in the display location 320.

First, on the display screen 301K, the anomaly handling proposal based  
15 on the anomaly occurrence handling data 166a is displayed. As described subsequently with reference to Fig. 5 and Fig. 6, the operator judges, from the content displayed on the display screen 301K, whether or not the construction work should be continued as is in view of an anomalous situation such as trouble correction, maintenance, weather, or change in client demands  
20 (discovery of historic remains, etc.). In cases where the level of importance of performing maintenance or trouble correction is low, for example, a decision is made not to adopt a revised Gantt chart. In such cases, the operator of the leader work machine 31 will direct the progress of the plurality of work machines 31 to 35 so that the construction work is carried on according to the  
25 pre-revision Gantt chart.

Thus the operator of the leader work machine 31 also fulfills the role of a general site foreman who judges whether or not to continue construction

work as is in the face of an anomalous situation such as unscheduled maintenance.

In cases where the level of importance of the maintenance or trouble correction is high, on the other hand, a decision is made to adopt a revised Gantt chart, and the display screen 301K of the monitor device 300 is changed from the state wherein the anomaly handling proposal is displayed to one wherein the revised Gantt chart is displayed.

Every time the select next candidate button 322 is pressed, the revised 3D Gantt chart displayed in the display location 320 changes sequentially from the construction period priority Gantt chart to the budget priority Gantt chart to the environment priority Gantt chart. Thereupon, when the decision button 321 is pressed, the revised 3D Gantt chart (say the construction period priority Gantt chart, for example) being displayed currently in the display location 320 is determined on.

When the revised 3D Gantt chart is determined on, the display content diagrammed in Fig. 10, 11, and 12 changes from that prior to revision to the content of the Gantt chart determined on after revision.

Data indicating the determined 3D Gantt chart (the construction period priority Gantt chart, for example) are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5 and stored in the 3D Gantt chart schedule and performance results database 141A in the database 100. Thus the "scheduled" data of the 3D Gantt chart schedule and performance results database 141A corresponding to the construction company 30A are updated.

In this manner, the operator of the leader work machine 31 can also fulfill the role of a general site manager who revises Gantt charts.

The number of construction machines noted in the revised Gantt chart is sometimes a greater number than that noted in the Gantt chart prior to revision.

Thereupon, when a password or the like is input from the terminal device 31a of the leader work machine 31 and the machines on hand  
5 information 203 stored in the database 100 is accessed, the machines on hand information 203 is transmitted to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory in the terminal device, and displayed on a display screen.

10 Thereupon, if the operator of the leader work machine 31 enters vehicle deployment request data from the terminal device 31a, in like manner as described earlier, the required number of construction machines can be quickly secured from the lease company 90a and/or rental company 90b.

In this manner, the operator of the leader work machine 31 can also  
15 fulfill the role of a general site manager who makes arrangements for the deployment of vehicles in accordance with revised Gantt charts.

The revised 3D Gantt chart proposal information 166 comprises  
follower-machine 3D Gantt chart information 165'. The follower-machine 3D  
Gantt chart information 165' is transmitted from the terminal device 31a of the  
20 leader work machine 31 in construction phase 1 to the terminal devices of the follower machines 32, 33, 34, and 35 via the radio communication links 6, stored in memory in the terminal devices, and displayed on display screens in the monitor devices 300.

In this manner, the operator of the leader work machine 31, in cases  
25 where the Gantt chart is revised, is able to fulfill the role also of a general site manager in informing the operators of affected construction machines that there has been a revision so that the work can be performed according to the revised content of the revised Gantt chart.

Thereafter, the operators of the follower machines 32, 33, 34, and 35 in construction phase 1 can accomplish the work that should be performed by their vehicles in accordance with the follower-machine 3D Gantt chart information 165' displayed on the display screen of the monitor device 300 in each of their own vehicles.

While construction work is being carried on in construction phase 1, the operator of the leader work machine 31 checks the progress of the work being done by his or her own vehicle 31 and by the follower machines 32 to 35 based on the content displayed on the display screen 301 represented in Fig. 10, 11, and 12. If the work is delayed, that operator instructs the follower machines 32 to 35 via the radio communication links 6 to make up for that delay. The operator of the leader work machine 31 also informs the follower machines 32 to 35 of operating ranges, via the radio communication links 6, based on the content displayed on the display screen 301 indicated in Fig. 10, 11, and 12.

A case where a Gantt chart is revised is now described specifically with reference to Fig. 10, 11, and 12.

The "initial plan" for a construction phase 1 called for starting the construction work on August 2 and finishing it on August 20. According to the long-range regional weather forecast (regional specific weather statistics database 111), it was to be "raining" on August 18. According to the regional specific detailed weather information 175, however, "rain" was forecast for August 11, wherefore a change was made to a "revised plan" according to which operations would be suspended on August 11 but carried on on the holidays August 14 and August 21. In Fig. 10 here, operating days in the modified plan, and days on which the plan progressed according to schedule, respectively, are indicated by being blacked out. As indicated in Fig. 10, moreover, when operations were implemented according to the modified plan, construction phase 1 was completed according to the initial daily schedule.

In the foregoing, the operations of the leader work machine 31 and the follower machines 32 to 35 in construction phase 1 are described, but the leader work machine 36 and follower machines 33, 37, 38, and 39 in construction phase 2, and the leader work machine 33 and the follower machines 40 and 41 in construction phase 3 operate in like manner.

Next, a specific description is given of the content of processing done when the anomaly of the arrival of an unscheduled maintenance time occurs during construction work, making reference to Fig. 5.

Vehicle condition data 200b, namely hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control input signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k, are detected by sensor groups provided in the follower machines 32 to 35.

The vehicle condition data 200b detected in the follower machines 32 to 35 are transmitted together with the vehicle ID data 200s to the leader work machine 31 via a radio communication link 6.

The vehicle ID data and vehicle condition data 200 detected at the plurality of follower machines 32 to 35, together with the vehicle ID data and vehicle condition data 200 detected at the leader work machine 31, are transmitted from the fan 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

A description is now given assuming the case where a time for unscheduled maintenance has arrived in the follower machine 35.

In the server apparatus 11, when the vehicle ID data 200a for the follower machine 35 are transmitted, the type "B" and model "model 1" corresponding to the vehicle ID data 200a (B-35) are read out from the machine type and model specific machine number database 160. It is assumed



here that an association has been effected in the machine type and model specific machine number database 160 such that the machine number "35" corresponds to the model "model 1" (step 401).

Next, the standard condition data corresponding to the type "B" and the model "model 1" are read out from the machine specific standard condition data database 151. Next, a comparison is made between the standard condition data so read out, and the vehicle condition data 200b for the follower machine 35 associated with the vehicle ID data 200a (B-35) for the follower machine 35, and a judgment is made as to whether the vehicle condition is normal or anomalous.

The content of the standard condition data is exemplified in Fig. 17(a).

In the standard condition data indicated in Fig. 17(a), standard values for the sensor detection values a, b, c, d, e, and g for every lever control signal f1, f2, and f3, that is, every work condition f1, f2, and f3, are set. When the work condition is f1, for example, the condition is judged to be anomalous if any one of the sensor detection values a, b, c, d, e, or g is equal to or greater (or equal to or less than, depending on the sensor type) than a1, b1, c1, d1, e1, or g1 respectively, but is otherwise judged to be normal (step 402).

As a result of the judgment made in step 402, when the condition is "anomalous," a further judgment is made as to whether or not it is possible to continue operating without performing maintenance.

Specifically, the limiting condition data corresponding to the type "B" and the model "model 1" are read out from the machine specific limiting condition data database 156. Next, a comparison is made between the limiting condition data so read out, and the vehicle condition data 200b for the follower machine 35 associated with the vehicle ID data 200a (B-35) for the follower machine 35, and a judgment is made as to whether or not it is possible to continue operating without performing maintenance. In this case, the sensor

detection values and the limiting condition data are compared in the same manner as in Fig. 17(a) (step 403).

When the judgment made in step 403 is to the effect that "continued operation impossible," processing is done next to specify the maintenance location and retrieve three-dimensional shape data on the maintenance location.

That is, maintenance failure fatality level data corresponding to the type "B" and the model "model 1" are read out from the maintenance failure fatality level database 157. Next, a comparison is made between the maintenance failure fatality level data so read out, and the vehicle condition data 200b for the follower machine 35 associated with the vehicle ID data 200a (B-35) for the follower machine 35, and the maintenance location is specified.

In Fig. 17(b) is exemplified the content of maintenance failure fatality level data that specifies "engine oil filter replacement" as the maintenance location.

In the maintenance failure fatality level data, as diagrammed in Fig. 17(b), standard values for the specified sensor detection values a, b, e, and g are established for each lever control input signal f4, f5, and f6, that is, for each work condition f4, f5, and f6. When the work condition is f4, for example, the judgment "oil filter replacement necessary" is made when any of the specified detection values a, b, e, or g is equal to or greater (or equal to or less than, depending on the sensor type) than the standard value a4, b4, e4, or g4 respectively, but is otherwise judged to be normal (step 402); otherwise the judgment "oil filter replacement unnecessary" is made. Similar judgments are made for the other maintenance locations, and locations where maintenance should be performed are specified. When, as a result, the judgment "oil filter replacement necessary" is made, three-dimensional shape (3D) data for the maintenance location (vicinity of where the engine oil filter is attached) and for

the replacement part (oil filter) are read out from the 3D parts shape database 161 (step 404).

Next, when it is necessary to replace a part in performing the maintenance, data on whether or not that part is in inventory in a warehouse of the construction company 30A that is in possession of the follower machine 35 are retrieved from data stored in the internal company 30A parts inventory database 143A, and that part is requisitioned (step 405).

If the part is not in inventory in the warehouse of the construction company 30A, data requesting a confirmation of the warehouse search for the part and the date and time of part arrival are transmitted from the server apparatus 11 to the terminal device 21 of the parts depot 20 via a radio communication link 5, communication satellite 3, and radio communication link 5, the availability of the part and the date and time of part arrival are queried, and the part is requisitioned. As a result, from the terminal device 21 of the parts depot 20, data indicating the results of the search for the part (parts inventory, parts arrival date) are transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5 (step 406).

Next, data requesting the date and time of the arrival of service personnel at the construction site, and the repair time (from arrival at construction site to completion of repairs) are transmitted from the server apparatus 11 to the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5, and the date and time of arrival of the service personnel and the repair time are queried. As a result, data indicating the results of the retrieval of the date and time of arrival of the service personnel and the repair time are transmitted from the terminal device 23 of the service point 22 to the server

apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5 (step 407).

In steps 405, 406, and 407, a part value corresponding to the type "B" and model "model 1" replacement part "oil filter" is read out from the service parts price database 132. Also, the service fees corresponding to the type "B" and model "model 1" replacement part "oil filter" are read out from the service fee database 131. By service fees, here, are meant fees that include both the fees for dispatching service personnel established according to the distance from the service point 22 to the construction site, and the labor cost required for the repair (part replacement). Also, the maintenance time required (repair time) corresponding to the type "B" and model "model 1" replacement part "oil filter" is read out from the maintenance time required data database 158. By maintenance time required (repair time) here is meant the time required for the repair (part replacement) at the construction site.

Next, taking the maintenance time required (repair time) into consideration, the initial 3D Gantt chart is revised in the same manner as described for step 705 in Fig. 7.

That is, the similar construction work selection system 706, in like manner as in step 705 in Fig. 7, retrieves data on past construction work wherein the Gantt chart was revised by unscheduled maintenance u (oil filter replacement) from data stored in the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D, and revises the Gantt chart, according to the current unscheduled maintenance u, so that the construction work is completed within the construction period s (step 408).

Thus data indicating revised Gantt charts for the construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart are produced as revised 3D Gantt chart data 166b.

Also, data indicating a handling proposal for handling the anomalous situation constituted by unscheduled maintenance are produced as anomaly occurrence handling data 166a.

The anomaly occurrence handling data 166a are configured by required maintenance location 3D shape data 166c indicating the three-dimensional shapes of maintenance locations acquired in steps 404 to 407, requisitioned part 3D shape and part arrival date and time data 167a indicating the three-dimensional shape of requisitioned parts and the date and time the parts are to arrive, service personnel arrival date and time and repair time data 167b indicating the date and time service personnel will arrive at the construction site and the time required for repair, and parts price and service cost data 182 indicating the prices of parts and service fees. These anomaly occurrence handling data 166a and revised 3D Gantt chart data 166b indicating revised three-dimensional Gantt charts are transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in memory in the terminal device 31a.

Therefore, in the display location 320 on the display screen 301A of the monitor device 300 carried on board the leader work machine 31 is displayed the three-dimensional shape of the location where maintenance is required (the vicinity of where the engine oil filter is attached), based on the required maintenance location 3D shape data 166c, as diagrammed in Fig. 5. From that display content, the operator can judge whether or not maintenance should be performed immediately.

The operator of the leader work machine 31 decides, from the content displayed on the display screen 301A, whether or not maintenance should be performed immediately and the construction work continued according to a revised Gantt chart. When it is decided that maintenance should be performed

immediately, the decision button 321 on the display screen 301A is pressed. When it is decided that further study is required, the select next candidate button 322 on the display screen 301A is pressed.

As a result, the display screen 301A transitions to the display screen 301B.

In the display location 320 on the display screen 301B are displayed the three-dimensional shape of the requisitioned part and the date and time the requisitioned part is to arrive at the construction site, based on the requisitioned part 3D shape and part arrival date and time data 167a, and the date and time service personnel are to arrive at the construction site, and the repair time, based on the service personnel arrival date and time and repair time data 167b, and the price of the part and the service cost, based on the parts price and service cost data 182. The operator, from that displayed content, can make a more careful decision as to whether or not maintenance should be performed immediately.

The operator of the leader work machine 31 decides, from the content displayed on the display screen 301B, whether or not maintenance should be performed immediately and the construction work continued according to a revised Gantt chart. When it is decided that maintenance should be performed immediately, the decision button 321 on the display screen 301B is pressed. When it is decided that further study is required, the select next candidate button 322 on the display screen 301B is pressed.

As a result, the display screen 301B transitions to the display screen 301C.

In the display location 320 on the display screen 301C, the revised 3D Gantt chart candidate is displayed, based on the revised 3D Gantt chart data 166b. Every time the select next candidate button 322 is pressed, the revised 3D Gantt chart candidate currently being displayed in the display location 320

changes sequentially to the next revised 3D Gantt chart candidate. When the revised 3D Gantt chart currently displayed in the display location 320 is to be definitely determined on, the decision button 321 is pressed.

When the decision button 321 is pressed, data instructing that maintenance is to be performed are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. From the server apparatus 11, data instructing the requisitioning of a part are transmitted to the terminal device 21 of the parts depot 20 via a radio communication link 5, communication satellite 3, and radio communication link 5, and data instructing the requisitioning of service personnel are transmitted to the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5. Thus the parts and the service personnel will arrive at the construction site, and maintenance will be performed on the construction machine 35. In cases where it is impossible to make the repair at the construction site, the construction machine will be conveyed to the repair shop and the repair made there (step 409).

When the maintenance is finished, the parts depot 20 and service point 22 compute the parts price and service costs. Then, from the terminal device 21 of the parts depot 20, data requesting the parts price, and from the terminal device 23 of the service point 22, data requesting the service cost are input, and transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. At the server apparatus 11, the prices of parts are retrieved based on data stored in the machine specific service parts price database 132, service costs are retrieved based on data stored in the service fee database 131, and those data are transmitted to the terminal device 21 of the parts depot 20 and the terminal

device 23 of the service point 22 via a radio communication link 5,  
communication satellite 3, and radio communication link 5. Thus the service  
company 20' (parts depot 20, service point 22) can easily and quickly acquire  
parts prices and service costs by accessing the database 100 in the server  
5 apparatus 11.

Thereupon, data requesting a parts price from the construction company  
30A are input to the terminal device 21 of the parts depot 20, and data  
requesting repair particulars and service costs from the construction company  
30A are input to the terminal device 23 of the service point 22. These data are  
10 transmitted to the server apparatus 11 via a radio communication link 5,  
communication satellite 3, and radio communication link 5. The server  
apparatus 11 transmits those data to the terminal device 31a of the leader work  
machine 31 via a radio communication link 5, communication satellite 3, and  
radio communication link 5, and stores those data in memory in the terminal  
15 device 31a.

Thus, in the display location 320 on the display screen 301D of the  
monitor device 300 carried on board the leader work machine 31, the repair  
particulars and invoice amount (parts prices and service costs) are displayed.

When the operator has received those display contents and indicated an  
20 intent to pay (acceptance possible), button 321 is pressed. If there are troubles  
with the content displayed and receipt is not possible (acceptance not possible),  
button 322 is pressed.

When button 322 is pressed on the display screen 301D, data indicating  
acceptance not possible are input to the terminal device 31a of the leader work  
25 machine 31 and transmitted to the server apparatus 11 via a radio  
communication link 5, communication satellite 3, and radio communication  
link 5. The server apparatus 11 transmits those data to the terminal device 21  
of the parts depot 20 and the terminal device 23 of the service point 22 via a



radio communication link 5, communication satellite 3, and radio communication link 5. Thereupon, the parts depot 20 and service point 22 review the parts prices and service costs and transmit the parts prices and service costs obtained as a result, in the same manner as before, to the terminal device 31a of the leader work machine 31 via the server apparatus 11.

When button 321 on the display screen 301D is pressed, data indicating acceptance possible are input to the terminal device 31a of the leader work machine 31 and transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. The server apparatus 11 performs processing, by means of electronic settlement, to withdraw funds in payment of fees from a designated account of the construction company 30A and transfer the withdrawn funds in payment of fees to a designated account of the service company 20'.

The server apparatus 11 stores service history data indicating maintenance content (parts replacement, repair particulars) and invoice amounts (parts prices, service costs) in the 30A company service history database 142A, and updates the content stored in the 30A company service history database 142A. In this manner, service history data are stored, categorized by construction company, i.e. whether for construction company 30A, 50B, 60C, or 70D, by type and model of construction machine, and by particulars of construction work (step 410). The processing performed in steps 401 to 410 was described representatively for the follower machine 35, but that processing is performed in the same manner for the other construction machines 31 and 32 to 34.

Thus the operator of the leader work machine 31, when maintenance has been performed, is able to fulfill also the role of office manager (labor manager) in performing processing to settle invoices for the costs of such maintenance, and take measures to transfer funds to the proper parties.

The operator of the leader work machine 31, furthermore, from the content displayed on the display screen 301A, 301B or 301C, can decide to continue the construction work as is without revising the Gantt chart for the anomalous situation constituted by unscheduled maintenance.

5 In a case where there is but little time remaining until a construction phase is completed and the level of importance of the maintenance is low, for example, he or she can decide not to employ a revised Gantt chart. In that case, the operator of the leader work machine 31 would direct the work progress of the plurality of work machines 31 to 35 so that the construction work is carried  
10 on according to the Gantt chart prior to revision.

Thus the operator of the leader work machine 31 is able also to fulfill the role of a general site foreman in deciding whether or not to continue the construction work as is in the face of unscheduled maintenance.

When the decision button 321 on the display screen 301C is pressed, the  
15 revised 3D Gantt chart is determined on, and the display content diagrammed in Fig. 10, 11, and 12 is changed from the content of that prior to revision to the content of the Gantt chart after revision.

Data indicating the determined 3D Gantt chart (such as the construction period priority Gantt chart, for example) are transmitted from the terminal  
20 device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in the 3D Gantt chart schedule and performance results database 141A of the database 100. The "scheduled" data in the 3D Gantt chart schedule and performance results database 141A corresponding to the  
25 construction company 30A is thereby updated.

Thus the operator of the leader work machine 31 is able also to fulfill the role of a general site manager in revising Gantt charts.

The number of construction machines noted in the revised Gantt chart is sometimes a greater number than that noted in the Gantt chart prior to revision.

Thereupon, when a password or the like is input from the terminal device 31a of the leader work machine 31 and the machines on hand  
5 information 203 stored in the database 100 is accessed, the machines on hand information 203 is transmitted to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory in the terminal device, and displayed on a display screen.

10 Thereupon, if the operator of the leader work machine 31 enters vehicle deployment request data from the terminal device 31a, in like manner as described earlier, the required number of construction machines can be quickly secured from the lease company 90a and/or rental company 90b.

In this manner, the operator of the leader work machine 31 can also  
15 fulfill the role of a general site manager who makes arrangements for the deployment of vehicles in accordance with revised Gantt charts.

The revised 3D Gantt chart proposal information 166 comprises follower-machine 3D Gantt chart information 165'. The follower-machine 3D Gantt chart information 165' is transmitted from the terminal device 31a of the  
20 leader work machine 31 in construction phase 1 to the terminal devices of the follower machines 32, 33, 34, and 35 via the radio communication links 6, stored in memory in the terminal devices, and displayed on display screens in the monitor devices 300.

In this manner, the operator of the leader work machine 31, in cases  
25 where the Gantt chart is revised, is able to fulfill the role also of a general site manager in informing the operators of related construction machines that there has been a revision so that the work can be performed according to the revised content of the revised Gantt chart.

Thereafter, the operators of the follower machines 32, 33, 34, and 35 in construction phase 1 can accomplish the work that should be performed by their vehicles in accordance with the follower-machine 3D Gantt chart information 165' displayed on the display screen of the monitor device 300 in each of their own vehicles.

While construction work is being carried on in construction phase 1, the operator of the leader work machine 31 checks the progress of the work being done by his or her own vehicle 31 and by the follower machines 32 to 35 based on the content displayed on the display screen 301 represented in Fig. 10, 11, and 12. If the work is delayed, that operator instructs the follower machines 32 to 35 via the radio communication links 6 to make up for that delay. The operator of the leader work machine 31 also informs the follower machines 32 to 35 of operating ranges, via the radio communication links 6, based on the content displayed on the display screen 301 indicated in Fig. 10, 11, and 12.

In the foregoing, the operations of the leader work machine 31 and the follower machines 32 to 35 in construction phase 1 are described, but the leader work machine 36 and follower machines 33, 37, 38, and 39 in construction phase 2, and the leader work machine 33 and the follower machines 40 and 41 in construction phase 3 operate in like manner.

With reference to Fig. 10, 11, and 12, judgment examples for cases where an anomalous situation constituted by unscheduled maintenance has occurred are described specifically.

(Example 1) The "initial plan" for a construction phase 1 calls for starting the construction work on August 2 and finishing it on August 20.

Thereupon, information to the effect that maintenance is to be performed on the follower machine 35 on August 19 is transmitted to the leader work machine 31. However, August 19 is right before construction phase 1 is to be completed, and the follower machine 35 is a construction machine that is not

scheduled for operation in construction phase 2 or construction phase 3, wherefore the operator of the leader work machine 31 decided not to perform maintenance on the follower machine 35 during construction phase 1. Hence construction phase 1 was completed according to the initial plan.

5 (Example 2) The "initial plan" for construction phase 2 calls for starting the construction work on August 16 and finishing it on September 10.

According to the long-range regional weather forecast (regional specific weather statistics database 111), it was to be "raining" on August 18.

According to the regional specific detailed weather information 175, however,

10 "rain" was forecast for August 19 and September 2, wherefore a change was made to a "revised plan" according to which operations would be suspended on August 19 and September 2 but carried on on the holiday August 22.

Thereupon, information that maintenance is to be performed on the follower machine 39 on August 19 was transmitted to the leader work machine 36.

15 August 19 was a non-operating day on which "rain" was forecast, wherefore the judgment was made that maintenance could be performed on the follower machine 39 without affecting the job, and that maintenance was performed.

Thus construction phase 2 work was carried on according to the revised plan without the daily schedule being delayed.

20 Next, with reference to Fig. 6, the content of processing performed in a case where the anomaly of having to correct a trouble during the construction work has occurred is described specifically.

Vehicle condition data 200b, namely hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control input  
25 signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k, are detected by sensor groups provided in the follower machines 32 to 35.

The vehicle condition data 200b detected in the follower machines 32 to 35 are transmitted together with the vehicle ID data 200a to the leader work machine 31 via a radio communication link 6.

The vehicle ID data and vehicle condition data 200 detected at the plurality of follower machines 32 to 35, together with the vehicle ID data and vehicle condition data 200 detected at the leader work machine 31, are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

A description is now given assuming the case where an anomaly such as a trouble has occurred in the follower machine 33.

In the server apparatus 11, when the vehicle ID data 200a for the follower machine 33 are transmitted, the type "P" and model "model 2" corresponding to the vehicle ID data 200a (P-33) are read out from the machine type and model specific machine number database 160. It is assumed here that an association has been effected in the machine type and model specific machine number database 160 such that the machine number "33" corresponds to the model "model 2" (step 501).

Next, the standard condition data corresponding to the type "P" and the model "model 2" are read out from the machine specific standard condition data database 151. Next, a comparison is made between the standard condition data so read out, and the vehicle condition data 200b for the follower machine 33 associated with the vehicle ID data 200a (P-33) for the follower machine 35, and a judgment is made as to whether the vehicle condition is normal or anomalous, in the same manner as was described with Fig. 17(a) (step 502).

When the results of the decision made in step 502 is that the situation is "anomalous," further processing is performed to specify the anomalous phenomenon and the level of importance thereof. By anomalous phenomenon

here is meant something like "no power" or "poor fuel economy." And the level of importance is determined according to the amount of time left remaining until a part can no longer be used. The shorter the time remaining, the higher the level of importance.

5 That is, the anomalous phenomenon data corresponding to the type "P" and the model "model 2" are read out from the machine specific anomalous phenomenon data database 152. Next, a comparison is made between the anomalous phenomenon data so read out, and the vehicle condition data 200b for the follower machine 33 associated with the vehicle ID data 200a (P-33) for  
10 the follower machine 33, and the anomalous phenomenon and level of importance thereof are specified (step 503).

Next, processing is performed to specify the anomaly location and retrieve three-dimensional shape data for that anomaly location. By anomaly location here is meant a "hydraulic pump failure" or "damage to a working  
15 member" or the like.

More specifically, anomaly location data corresponding to the type "P" and the model "model 2" are read out from the machine specific anomaly location data database 154. Next, a comparison is made between the anomaly location data so read out and the vehicle condition data 200b for the follower  
20 machine 33 associated with the vehicle ID data 200a (P-33) for the follower machine 33, and the anomaly location is specified.

In Fig. 18 is exemplified the content of anomaly location data that specifies "hydraulic pump failure" and "damage to a working member" as anomaly locations.

25 As indicated in Fig. 18, standard values for specific sensor detection values are established for each anomaly location. For example, when a lever control input signal f7 (work condition f7) is effected, if the specific sensor detection values a and e are equal to or less than the standard values a7 and e7

respectively, a "hydraulic pump failure" is judged to have occurred. When a lever control input signal f8 (work condition f8) is effected, if the specific sensor detection values d and g are equal to or less than the standard values d8 and g8 respectively, "damage to a working member" is judged to have  
5 occurred.

As a result, when the anomaly location is specified, three-dimensional shape (3D) data for the anomaly location (vicinity of the hydraulic pump) and the part to be replaced (hydraulic pump assembly or a part configuring the hydraulic pump) are read out from the 3D parts shape database 161 (step 504).

10 Next, when it is necessary to replace a part (such as the hydraulic pump assembly, for example) in correcting the trouble, data on whether or not that part is in inventory in a warehouse of the construction company 30A that is in possession of the follower machine 33 are retrieved from data stored in the internal company 30A parts inventory database 143A, and that part is  
15 requisitioned (step 505).

If the part is not in inventory in the warehouse of the construction company 30A, data requesting a confirmation of the warehouse search for the part and the date and time of part arrival are transmitted from the server apparatus 11 to the terminal device 21 of the parts depot 20 via a radio  
20 communication link 5, communication satellite 3, and radio communication link 5, the availability of the part and the date and time of part arrival are queried, and the part is requisitioned. As a result, from the terminal device 21 of the parts depot 20, data indicating the results of the search for the part (parts inventory, parts arrival date) are transmitted to the server apparatus 11 via a  
25 radio communication link 5, communication satellite 3, and radio communication link 5 (step 506).

Next, data requesting the date and time of the arrival of service personnel at the construction site, and the repair time (from arrival at



construction site to completion of repairs) are transmitted from the server apparatus 11 to the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5, and the date and time of arrival of the service personnel and the repair time are queried. As a result, data indicating the results of the retrieval of the date and time of arrival of the service personnel and the repair time are transmitted from the terminal device 23 of the service point 22 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5 (step 507).

In steps 505, 506, and 507, a part value corresponding to the type "P" and model "model 2" replacement part "hydraulic pump assembly" is read out from the service parts price database 132. Also, the service fees corresponding to the type "P" and model "model 2" replacement part "hydraulic pump assembly" are read out from the service fee database 131. By service fees, here, are meant fees that include both the fees for dispatching service personnel established according to the distance from the service point 22 to the construction site, and the labor cost required for the repair (part replacement). Also, the maintenance time required (repair time) corresponding to the type "P" and model "model 2" replacement part "hydraulic pump assembly" is read out from the correction time data database 153. By correction time required (repair time) here is meant the time required for the correction (repair) at the construction site.

Next, taking the correction time (repair time) into consideration, the initial 3D Gantt chart is revised in the same manner as described for step 705 in Fig. 7.

That is, the similar construction work selection system 706, in like manner as in step 705 in Fig. 7, retrieves data on past construction work wherein the Gantt chart was revised by the correction v of a trouble

(replacement of hydraulic pump assembly) from data stored in the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D, and revises the Gantt chart, according to the current trouble correction v, so that the construction work is completed within the construction period s (step 508).

Thus data indicating revised Gantt charts for the construction period priority Gantt chart, budget priority Gantt chart, and environment priority Gantt chart are produced as revised 3D Gantt chart data 166b.

Also, data indicating a handling proposal for handling the anomalous situation constituted by the trouble correction are produced as anomaly occurrence handling data 166a.

The anomaly occurrence handling data 166a are configured by level of importance and anomaly location 3D shape data 166d indicating the level of importance and the three-dimensional shapes of anomaly locations acquired in steps 504 to 507, requisitioned part 3D shape and part arrival date and time data 167a indicating the three-dimensional shape of requisitioned parts and the date and time the parts are to arrive, service personnel arrival date and time and repair time data 167b indicating the date and time service personnel will arrive at the construction site and the time required for repair, and parts price and service cost data 182 indicating the prices of parts and service fees. These anomaly occurrence handling data 166a and revised 3D Gantt chart data 166b indicating revised three-dimensional Gantt charts are transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in memory in the terminal device 31a.

Therefore, in the display location 320 on the display screen 301E of the monitor device 300 carried on board the leader work machine 31 are displayed the level of importance (time remaining until the hydraulic pump can no longer

be used) and the three-dimensional shape of the anomaly location (vicinity of hydraulic pump), based on the level of importance and anomaly location 3D shape data 166d, as diagrammed in Fig. 6. From that display content, the operator can judge whether or not a correction should be made immediately.

5 The operator of the leader work machine 31 decides, from the content displayed on the display screen 301E, whether or not a correction should be made immediately and the construction work continued according to a revised Gantt chart. When it is decided that a correction should be made immediately, the decision button 321 on the display screen 301E is pressed. When it is  
10 decided that further study is required, the select next candidate button 322 on the display screen 301E is pressed.

As a result, the display screen 301E transitions to the display screen 301F.

15 In the display location 320 on the display screen 301F are displayed the three-dimensional shape of the requisitioned part and the date and time the requisitioned part is to arrive at the construction site, based on the requisitioned part 3D shape and part arrival date and time data 167a, and the date and time service personnel are to arrive at the construction site, and the repair time, based on the service personnel arrival date and time and repair  
20 time data 167b, and the price of the part and the service cost, based on the parts price and service cost data 182. From that displayed content, the operator can make a more careful decision as to whether or not a correction should be made immediately.

25 The operator of the leader work machine 31 decides, from the content displayed on the display screen 301F, whether or not a correction should be made immediately and the construction work continued according to a revised Gantt chart. When it is decided that a correction should be made immediately, the decision button 321 on the display screen 301F is pressed. When it is

decided that further study is required, the select next candidate button 322 on the display screen 301F is pressed.

As a result, the display screen 301F transitions to the display screen 301G.

5 In the display location 320 on the display screen 301G, the revised 3D Gantt chart candidate is displayed, based on the revised 3D Gantt chart data 166b. Every time the select next candidate button 322 is pressed, the revised 3D Gantt chart candidate currently being displayed in the display location 320 changes sequentially to the next revised 3D Gantt chart candidate. When the  
10 revised 3D Gantt chart currently displayed in the display location 320 is to be definitely determined on, the decision button 321 is pressed.

When button 321 is pressed, data instructing that a correction is to be made are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication  
15 satellite 3, and radio communication link 5. From the server apparatus 11, data instructing the requisitioning of a part are transmitted to the terminal device 21 of the parts depot 20 via a radio communication link 5, communication satellite 3, and radio communication link 5, and data instructing the  
20 requisitioning of service personnel are transmitted to the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5. Thus the parts and the service personnel will arrive at the construction site, and the correction will be made on the construction machine 35. In cases where it is impossible to make the repair at the construction site, the construction machine will be conveyed to the repair  
25 shop and the repair made there (step 509).

When the correction is finished, the parts depot 20 and service point 22 compute the parts price and service costs. Then, from the terminal device 21 of the parts depot 20, data requesting the parts price, and from the terminal

device 23 of the service point 22, data requesting the service cost are input, and transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. At the server apparatus 11, the prices of parts are retrieved based on data stored in the machine specific service parts price database 132, service costs are retrieved based on data stored in the service fee database 131, and those data are transmitted to the terminal device 21 of the parts depot 20 and the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5. Thus the service company 20' (parts depot 20, service point 22) can easily and quickly acquire parts prices and service costs by accessing the database 100 in the server apparatus 11.

Thereupon, data requesting a parts price from the construction company 30A are input to the terminal device 21 of the parts depot 20, and data requesting repair particulars and service costs from the construction company 30A are input to the terminal device 23 of the service point 22. These data are transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. The server apparatus 11 transmits those data to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stores those data in memory in the terminal device 31a.

Thus, in the display location 320 on the display screen 301H of the monitor device 300 carried on board the leader work machine 31, the repair particulars and invoice amount (parts prices and service costs) are displayed.

When the operator has received those display contents and indicated an intent to pay (acceptance possible), button 321 is pressed. If there are troubles

with the content displayed and receipt is not possible (acceptance not possible), button 322 is pressed.

When the button 322 is pressed on the display screen 301H, data indicating acceptance not possible are input to the terminal device 31a of the leader work machine 31 and transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. The server apparatus 11 transmits those data to the terminal device 21 of the parts depot 20 and the terminal device 23 of the service point 22 via a radio communication link 5, communication satellite 3, and radio communication link 5. Thereupon, the parts depot 20 and service point 22 review the parts prices and service costs and transmit the parts prices and service costs obtained as a result, in the same manner as before, to the terminal device 31a of the leader work machine 31 via the server apparatus 11.

When button 321 on the display screen 301H is pressed, data indicating acceptance possible are input to the terminal device 31a of the leader work machine 31 and transmitted to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. The server apparatus 11 performs processing, by means of electronic settlement, to withdraw funds in payment of fees from a designated account of the construction company 30A and transfer the withdrawn funds in payment of fees to a designated account of the service company 20'.

The server apparatus 11 stores service history data indicating maintenance and correction content (parts replacement, repair particulars) and invoice amounts (parts prices, service costs) in the 30A company service history database 142A, and updates the content stored in the 30A company service history database 142A. In this manner, service history data are stored, categorized by construction company, i.e. whether for construction company 30A, 50B, 60C, or 70D, by type and model of construction machine, and by

particulars of construction work (step 410). The processing performed in steps 501 to 510 was described representatively for the follower machine 33, but that processing is performed in the same manner for the other construction machines 31, 32, 34, and 35.

5        Thus the operator of the leader work machine 31, when trouble correction has been effected, is able to fulfill also the role of office manager (labor manager) in performing processing to settle invoices for the costs of such maintenance, and take measures transfer funds to the proper parties.

10       The operator of the leader work machine 31, furthermore, from the content displayed on the display screen 301E, 301F or 301G, can decide to continue the construction work as is without revising the Gantt chart for the anomalous situation constituted by the trouble correction.

15       In a case where the level of importance is low and there is but little time remaining until a construction phase is completed, for example, he or she can decide not to employ a revised Gantt chart. In that case, the operator of the leader work machine 31 would direct the work progress of the plurality of work machines 31 to 35 so that the construction work is carried on according to the Gantt chart prior to revision.

20       Thus the operator of the leader work machine 31 is able also to fulfill the role of a general site foreman in deciding whether or not to continue the construction work as is when a trouble arises.

25       When the decision button 321 on the display screen 301C is pressed, the revised 3D Gantt chart is determined on, and the display content diagrammed in Fig. 10, 11, and 12 is changed from the content of that prior to revision to the content of the Gantt chart after revision.

      Data indicating the determined 3D Gantt chart (such as the construction period priority Gantt chart, for example) are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio

communication link 5, communication satellite 3, and radio communication link 5, and stored in the 3D Gantt chart schedule and performance results database 141A of the database 100. The "scheduled" data in the 3D Gantt chart schedule and performance results database 141A corresponding to the construction company 30A are thereby updated.

Thus the operator of the leader work machine 31 is able also to fulfill the role of a general site manager in revising Gantt charts.

The number of construction machines noted in the revised Gantt chart is sometimes a greater number than that noted in the Gantt chart prior to revision.

Thereupon, when a password or the like is input from the terminal device 31a of the leader work machine 31 and the machines on hand information 203 stored in the database 100 is accessed, the machines on hand information 203 is transmitted to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, stored in memory in the terminal device, and displayed on a display screen.

Thereupon, if the operator of the leader work machine 31 enters vehicle deployment request data from the terminal device 31a, in like manner as described earlier, the required number of construction machines can be quickly secured from the lease company 90a and/or rental company 90b.

In this manner, the operator of the leader work machine 31 can also fulfill the role of a general site manager who makes arrangements for the deployment of vehicles in accordance with revised Gantt charts.

The revised 3D Gantt chart proposal information 166 comprises follower-machine 3D Gantt chart information 165'. The follower-machine 3D Gantt chart information 165' is transmitted from the terminal device 31a of the leader work machine 31 in construction phase 1 to the terminal devices of the follower machines 32, 33, 34, and 35 via the radio communication links 6,



stored in memory in the terminal devices, and displayed on display screens in the monitor devices 300.

In this manner, the operator of the leader work machine 31, in cases where the Gantt chart is revised, is able to fulfill the role also of a general site manager in informing the operators of related construction machines that there has been a revision so that the work can be performed according to the revised content of the revised Gantt chart.

Thereafter, the operators of the follower machines 32, 33, 34, and 35 in construction phase 1 can accomplish the work that should be performed by their vehicles in accordance with the follower-machine 3D Gantt chart information 165' displayed on the display screen of the monitor device 300 in each of their own vehicles.

While construction work is being carried on in construction phase 1, the operator of the leader work machine 31 checks the progress of the work being done by his or her own vehicle 31 and by the follower machines 32 to 35 based on the content displayed on the display screen 301 represented in Fig. 10, 11, and 12. If the work is delayed, that operator instructs the follower machines 32 to 35 via the radio communication links 6 to make up for that delay. The operator of the leader work machine 31 also informs the follower machines 32 to 35 of operating ranges, via the radio communication links 6, based on the content displayed on the display screen 301 indicated in Fig. 10, 11, and 12.

In the foregoing, the operations of the leader work machine 31 and the follower machines 32 to 35 in construction phase 1 are described, but the leader work machine 36 and follower machines 33, 37, 38, and 39 in construction phase 2, and the leader work machine 33 and the follower machines 40 and 41 in construction phase 3 operate in like manner.

With reference to Fig. 10, 11, and 12, judgment examples for cases where an anomalous situation constituted by unscheduled maintenance has occurred are described specifically.

The "initial plan" for a construction phase 1 calls for starting the construction work on August 2 and finishing it on August 20. Thereupon, information to the effect that a failure was to be repaired on the follower machine 33 on August 19 and 20 was transmitted to the leader work machine 31. The level of importance of this trouble was high, and the follower machine 33 was a construction machine that was scheduled for operation both in construction phase 2, which was to follow, and in construction phase 3. Therefore, the operator of the leader work machine 31 judged that the trouble in the follower machine 33 should be corrected, and effected the correction. When the construction machines 31, 33, 34, and 35 were caused to be operated on August 21, which was a holiday, in order to make up the delay caused by correcting the trouble, construction phase 1 was completed according to the initial daily schedules.

Next, the content displayed on the monitor device 300 carried on board the follower machines 32 to 35 in construction phase 1 is described with reference to Fig. 13 to 16.

As described earlier, the follower-machine 3D Gantt chart information 165' is transmitted from the terminal device 31a of the leader work machine 31 to the terminal devices of the follower machines 32, 33, 34, and 35 via the radio communication links 6, stored in memory in the terminal devices, and displayed on display screens on the monitor devices 300. Jobs to be performed by the individual follower machines are described in the follower-machine 3D Gantt chart information 165'.

In Fig. 13 is represented an example display on the monitor device 300 for the follower machine 33 (a hydraulic shovel).

On the display screen of the monitor device 300 of the follower machine 33, as diagrammed in this Fig. 13, are displayed a "work process chart," a "daily schedule for today," and "particulars of work."

In the "work process chart," the work performance results for the follower machine 33 up until today and the scheduled work to be done today are indicated comparatively by a bar graph. In Fig. 13, the portion blacked in represents the work performance results up until today, and the hashed portion the scheduled work to be done today.

In "daily schedule for today," all of the construction machines 31 to 35 are further divided into a plurality of groups and the content of the work to be performed today by each group is noted in plain language.

And, in "particulars of work," the content of the work to be performed today by the follower machine 33 is noted in plain language.

The content of the work to be done today by the follower machine 33 can be graphically displayed.

When a prescribed button on the screen is clicked on, the display screen diagrammed in Fig. 13 transitions to the display screen diagrammed in Fig. 14.

On the display screen of the monitor device 300, as diagrammed in Fig. 14, the content of the work to be performed today by the follower machine 33 is displayed graphically as a hatched area.

When a prescribed button on the screen is clicked on, the display screen diagrammed in Fig. 14 transitions to the display screen diagrammed in Fig. 15, and when a prescribed button on the display screen diagrammed in Fig. 15 is clicked on, the display screen diagrammed in Fig. 16 is transitioned to.

Fig. 15 and 16 represent the content displayed in Fig. 14 with the point of view changed. Fig. 15 displays the construction site as seen from the side, while Fig. 16 displays the construction site as seen from above.

10093752650  
101101

5 The work performance results for the follower machine 33 can be estimated from the lever control input signals f output from sensors on the follower machine 33 and the hour meter time elapsed g. The work condition can be detected from the lever control input signals f, and the engine operating hours can be detected from the hour meter time elapsed g. Hence a daily work report indicating the actual operating time in one day for the follower machine 33 can be produced on the basis of the hour meter time elapsed g. Also, the volume excavated by the follower machine 33, that is, the work performance results therefor, can be estimated on the basis of the lever control input signals f and the hour meter time elapsed g.

15 The vehicle condition data 200b constituted by the lever control input signals f and the hour meter time elapsed g are detected by the sensor group provided in the follower machine 33. The vehicle condition data 200b detected in the follower machine 33, together with the vehicle ID data 200a, are transmitted to the leader work machine 31 via a radio communication link 6. These vehicle ID data and vehicle condition data 200 are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

20 At the server apparatus 11, the work performance results are computed on the basis of the lever control input signals f and hour meter time elapsed g detected at the follower machine 33. The work performance results for the other construction machines 31, 32, 34, and 35 are computed in the same manner. By estimating the work performance results for these construction machines 31 to 35, furthermore, the overall work performance results for the plurality of construction machines 31 to 35 are computed. The "performance results" column in the 3D Gantt chart diagrammed in Fig. 10, 11, and 12 is automatically written to by those computed work performance results. Also,

the "performance results" data in the 3D Gantt chart schedule and performance results database 141A corresponding to the construction company 30A are renewed by the work performance results computed as described above.

When the "performance results" column in the 3D Gantt chart diagrammed in Fig. 10, 11, and 12 is automatically written to by the server apparatus 11, those data are transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in memory in the terminal device 31a. Therefore, the 3D Gantt chart wherein the "performance results" column is written to is displayed on the display screen of the monitor device 300 in the leader work machine 31. At the time of construction phase 1 completion, moreover, the overall "performance results" are displayed graphically in the Gantt chart diagrammed in Fig. 10, 11, and 12.

Embodiment is also possible such that, instead of the "performance results" column of the 3D Gantt chart being automatically written to by the server apparatus 11, it is written to manually by the operator of the leader work machine 31.

In that case, the operator of the leader work machine 31 operates the button 311 indicated in Fig. 12, and writes in the "performance results" for each of the construction machines 31 to 35 that are displayed in the display location 320. He or she also writes in the "performance results" for all of the construction machines 31 to 35. The data indicating the content so written in are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. Therefore, the "performance results" data in the 3D Gantt chart schedule and performance results database

141A corresponding to the construction company 30A are updated according to the content written in at the leader work machine 31.

In this manner, "performance results" are stored in the 3D Gantt chart schedule and performance results database 141A for each of the construction machines 31 to 35, that is, for each of the vehicle ID data 200a for the construction machines 31 to 35. The overall "performance results" for the construction machines 31 to 35 are also stored.

Thus the operator of the leader work machine 31 is also able to fulfill the role of a general site foreman in filling in the "performance results" column in Gantt charts.

Of the "performance results" data stored in the 3D Gantt chart schedule and performance results database 141A, those data associated with the vehicle ID data 200a for the follower machine 33 are transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5. Furthermore, those "performance results" data associated with the vehicle ID data 200a for the follower machine 33 are transmitted from the terminal device 31a of the leader work machine 31 to the terminal device of the follower machine 33 via a radio communication link 6 and stored in memory in the terminal device. Based on the data stored in that memory, in the "work process chart," as described earlier with Fig. 13, the work performance results up until today (indicated in black) are displayed with the bar graph.

The follower machine 33 is described representatively in the foregoing, but the content indicated in Fig. 13 to 16 for the other follower machines 32, 34, and 35 also is displayed in the same manner on the monitor device 300 of that operator's own vehicle. The same applies to the follower machines 33, 37,

38, and 39 in construction phase 2 and to the follower machines 40 and 41 in construction phase 3.

As set forth in the foregoing, on the display screens of the monitor devices 300 of the construction machines 31 to 41 in the construction site, a 3D Gantt chart will be displayed as a construction work daily schedule chart for operators so that it can be viewed by the operator of each construction machine.

Here, the data for the construction work daily schedule chart for operators may be processed into a construction work daily schedule chart for residents, to be viewed by residents living in the periphery of the construction site, and displayed on the vehicle-mounted signboard 47 mounted on the construction machine 31 (leader work machine 31). The data processing is performed by the server apparatus 11. Or the data may be processed by the terminal device 31a in the construction machine 31 (leader work machine 31).

The vehicle-mounted signboard 47 may be deployed on any one of the construction machines that are follower machines 32 to 35 other than the leader work machine 31, or on a plurality of those construction machines. In such cases, the data for the construction work daily schedule chart for residents are transmitted from the leader work machine 31 to the other follower machines 32 to 35 via the radio communication links 6, and displayed on the vehicle-mounted signboards 47 deployed on the follower machines 32 to 35.

The construction work daily schedule chart for residents may be a simplification of the construction work daily schedule chart for operators, for example, wherein the construction work schedule and performance results are graphically displayed by bar graphs or three-dimensional topographical maps. Whenever the 3D Gantt chart has been modified, moreover, the construction work daily schedule chart for residents is modified accordingly.





4) Provide fuel sensors in the construction machines 31 to 35 that indirectly measure concentrations of toxic substances in the exhaust gases (such as the CO<sub>2</sub> or NO<sub>x</sub> concentration) by detecting the volume of fuel consumed. Or, alternatively, provide concentration meters that directly  
5 measure concentrations of toxic substances in the exhaust gases (such as the CO<sub>2</sub> or NO<sub>x</sub> concentration).

5) Provide such fuel sensors or concentration meters in a main construction machine such as the leader work machine 31.

6) Provide a concentration meter at one or a plurality of prescribed  
10 locations at the construction site for directly measuring the concentrations of toxic substances in the air (such as the CO<sub>2</sub> or NO<sub>x</sub> concentration).

The data obtained by the noise-level meters and/or concentration meters (hereinafter called environmental condition data) are transmitted to the leader work machine 31, either from the follower machines 32 to 35 via the radio  
15 communication links 6, in like manner as the vehicle condition data 200b described earlier, or from installed noise-level meters and/or concentration meters via the radio communication links 6. Then, the leader work machine 31 transmits environmental condition data of the construction machines 31 to 35, inclusive of its own environmental condition data, or the environmental  
20 condition data measured by installed noise-level meters and/or concentration meters, to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5. At the server apparatus 11, the environmental condition data are processed into environmental condition data for residents which are to be viewed by residents.  
25 Then, from the server apparatus 11, the environmental condition data for residents are transmitted to the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and the environmental condition data for residents are displayed on the

vehicle-mounted signboard 47. On the vehicle-mounted signboard 47 may be displayed, for example, a noise graph wherein the daily construction work schedule (time) is plotted on the horizontal axis and noise level is plotted on the vertical axis, or a toxic substance concentration graph wherein the daily  
5 construction work schedule (time) is plotted on the horizontal axis and toxic substance concentrations (such as the CO<sub>2</sub> and/or NO<sub>x</sub> concentration) are plotted on the vertical axis.

The vehicle-mounted signboard 47 may be deployed on any one of the construction machines that are the follower machines 32 to 35 other than the  
10 leader work machine 31, or on a plurality of those construction machines. In such cases, the environmental condition data for residents are transmitted from the leader work machine 31 to the follower machines 32 to 35 via the radio communication links 6, and displayed on vehicle-mounted signboards 47 mounted on the follower machines 32 to 35.

When displayed on a stationary type signboard 57, the environmental  
15 condition data for residents may be transmitted from the server apparatus 11 to the stationary type signboard 57 via a radio communication link 5, communication satellite 3, and radio communication link 5, or, alternatively, they may be first transmitted to the leader work machine 51 and then via a  
20 radio communication link 6 to a stationary type signboard 57.

Based on this embodiment, as set forth in the foregoing, information relating to the construction site, such as the daily construction work schedule or environmental conditions or the like, can be presented to the residents living in the periphery of the construction site, accurately and in real time. Mutual  
25 understanding with the neighboring residents can therefore be better fostered than conventionally.

Furthermore, there is no need, as conventionally, for a person in charge of public relations to construction work schedules, performance results, and

noise-level meter readings by hand on a white board set up at the construction site.

Thus the operator of the leader work machine 31 or 51 can also fulfill the role of the person in charge of public relations in disseminating information relating to the construction site to the neighboring residents. Besides the information described in the foregoing, moreover, any information, such as the weather forecast for that region, for example, may be displayed on the vehicle-mounted signboard 47 or stationary type signboard 57.

Next, an embodiment that automatically produces daily work reports is described with reference to Fig. 8.

As described earlier, in the 3D Gantt chart schedule and performance results database 141A for the service provider company 10, "performance results" are written for each vehicle ID data 200a for the construction machines 31 to 35.

Thereupon, when the operator of the leader work machine 31 checks the daily work report for the follower machine 33, the vehicle ID data 200a for the follower machine 33, and data requesting the production of a daily work report for the follower machine 33, are input to the terminal device 31a. These data are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

As diagrammed in Fig. 8, the server apparatus 11 comprises a daily report data production system 185. The daily report data production system 185 is a system for producing data for the daily work report of the construction machine specified by the vehicle ID data 200a, based on data stored in the 3D Gantt chart schedule and performance results databases 141A, 141B, 141C, and 141D that are in the company specific history database group 140.

Now, when an instruction requesting that a daily work report be produced for the follower machine 33 is sent to the server apparatus 11, the daily report data production system 185 reads out "performance results" data corresponding to the follower machine 33 based on the vehicle ID data 200a from the 3D Gantt chart schedule and performance results database 141A and produces daily work report data 189 for the follower machine 33.

The daily work report data 189 is transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5 and stored in memory in the terminal device 31a.

Hence, as diagrammed in Fig. 8, in the display location 320 of the display screen 301L on the monitor device 300 carried on board the leader work machine 31, a daily work report for the follower machine 33, that is, the 1H actual operating time of the follower machine 33, is displayed graphically by a bar graph. The operator of the leader work machine 31 can thus perform operator labor management by, among other things, checking the daily work report displayed on that display screen 301L.

The operator of the leader work machine 31 can revise the daily work report displayed in the display location 320 on the display screen 301L. To do so, he or she presses button 322 on the display screen 301L, whereupon the display screen transitions to a revision screen. The daily work report can be revised on this revision screen. When it is judged that the content of the daily work report displayed in the display location 320 is correct, button 321 on the display screen 301L is pressed.

When button 321 on the display screen 301L is pressed, the finally determined daily work report data 189 are transmitted from the terminal device 31a of the leader work machine 31 to the terminal device 49 of the site office

30 via a radio communication link 5, communication satellite 3, and radio communication link 5.

In the terminal device 49 of the site office 30 are stored data and a program for a wage computation system 183. The wage computation system 183 is a system for computing wages for the operators on board the construction machines, based on the daily work report data 189.

Now, when the daily work report data 189 corresponding to the follower machine 33 are sent to the terminal device 49 of the site office 30, the wage computation system 183 computes the wages of the operator on board the follower machine 33, based on those daily work report data 189.

The terminal device 49 of the site office 30 also performs processing, by means of electronic settlement, to withdraw the amount of the wages so computed, from a designated account of the construction company A, and transfer that withdrawn amount of wages to a designated account of the operator on board the follower machine 33.

The follower machine 33 is described representatively in the foregoing, but daily work reports are produced automatically, and wages computed automatically, in the same manner for the other follower machines 31, 33, 34, and 35, and for the leader work machine 31.

Thus the operator of the leader work machine 31, by checking the daily work report, among other things, is able to fulfill the role of an office manager (labor manager) in performing operator labor management and implementing procedures for computing the wages to be paid to operators and transferring funds to those operators. Daily work reports are also automatically produced and wages automatically computed in like manner in construction phase 2 and construction phase 3.

The general site manager at the construction site must also produce a written construction report and submit it to the national government 92d that is

the client. Based on this embodiment, that written construction report can be automatically produced and automatically submitted to the national government 92d. In the written construction report are noted construction work delays, how much progress has been made, maintenance costs (parts prices, service costs) incurred during construction work, and trouble correction costs (parts prices, service costs).

More specifically, as described earlier, in the 3D Gantt chart schedule and performance results database 141A of the service provider company 10 are noted "performance results" for each vehicle ID data 200a for the construction machines 31 to 35. And in the service history database 142A of the service provider company 10 are stored, for each vehicle ID data 200a for the construction machines 31 to 35, service history data, that is, data indicating maintenance and correction particulars (parts replacement, repair particulars), and invoiced amounts (parts prices, service costs).

That being so, when the operator of the leader work machine 31 is to produce a written construction report for the follower machine 33, the vehicle ID data 200a for the follower machine 33 and data requesting the production of the written construction report for the follower machine 33 are input to the terminal device 31a. Those data are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

As diagrammed in Fig. 8, the server apparatus 11 comprises a construction work progress data production system 186. This construction work progress data production system 186 is a system for producing construction work progress data 190 that indicate how the construction work of the construction machine specified by the vehicle ID data 200a is progressing, based on the 3D Gantt chart schedule and performance results databases 141A,

141B, 141C, and 141D that are in the company specific history database group 140.

The server apparatus 11 also comprises a maintenance and correction cost data production system 187. The maintenance and correction cost data production system 187 is a system for producing maintenance and correction cost data 195 that indicate invoiced amounts paid for the construction machine specified by the vehicle ID data 200a, based on the service history databases 142A, 142B, 142C, and 142D that are in the company specific history database group 140.

Now, when an instruction requesting that a written construction report be produced for the follower machine 33 is sent to the server apparatus 11, the construction work progress data production system 186 reads out "performance results" data corresponding to the follower machine 33 based on the vehicle ID data 200a from the 3D Gantt chart schedule and performance results database 141A and produces construction work progress data 190 for the follower machine 33.

The maintenance and correction cost data production system 187 also reads out invoiced amount data corresponding to the follower machine 33 based on the vehicle ID data 200a from the service history database 142A, and produces maintenance and correction cost data 195 for the follower machine 33.

These construction work progress data 190 and maintenance and correction cost data 195 are transmitted from the server apparatus 11 to the terminal device 49 of the site office 30 via a radio communication link 5, communication satellite 3, and radio communication link 5.

In the terminal device 49 of the site office 30 are stored data and a program for a construction work progress management system 184. This construction work progress management system 184 is a system for producing

a written construction report for each construction machine based on the construction work progress data 190 and maintenance and correction cost data 195.

Now, when the construction work progress data 190 and maintenance and correction cost data 195 corresponding to the follower machine 33 are transmitted to the terminal device 49 of the site office 30, the construction work progress management system 184 produces a written construction report for the follower machine 33 based on the construction work progress data 190 and the maintenance and correction cost data 195.

The follower machine 33 is described representatively in the foregoing, but written construction reports are also produced automatically, in the same manner, for the other follower machines 31, 33, 34, and 35, and for the leader work machine 31.

Thus the operator of the leader work machine 31 can also fulfill the role of a general site manager in producing written construction reports. Written construction reports are also produced automatically, in the same manner, in construction phase 2 and construction phase 3.

Now, the operator of the leader work machine 31 in construction phase 1, because he or she oversees the other follower machines 32 to 35 in the construction site, is able to verify from the outside whether or not an overturn accident or theft incident has occurred with any of the follower machines 32 to 35 if during operating hours. However, such verification of overturn accident or theft cannot be verified if before or after the operating hours for the follower machines 32 to 35, or if such follower machines 32 to 35 have moved to a location where visual verification is not possible.

An embodiment is described next, with reference to Fig. 9, wherewith it is possible to discover that an overturn accident or theft has occurred with



either the leader work machine 31 or the follower machines 32 to 35, to contact the proper authorities, and to take appropriate measures immediately.

Let it first be assumed that the follower machine 33 in construction phase 1 has been stolen.

5 The vehicle condition data 200b consisting of the hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control input signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k are detected by the sensor group provided in the follower machine 33. Also, operator ID data 200c specifying the operator on board are  
10 associated with the follower machine 33. The vehicle condition data 200b detected in the follower machine 33, together with the vehicle ID data 200a, are transmitted via a radio communication link 6 to the leader work machine 31. These vehicle ID data and vehicle condition data 200 are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus  
15 11 via a radio communication link 5, communication satellite 3, and radio communication link 5.

In the 3D Gantt chart schedule and performance results database 141A of the service provider company 10 is stored the 3D Gantt chart information 165. As described earlier, the 3D Gantt chart information 165 has been  
20 provided with vehicle IDs that specify the types, models, and vehicle numbers of a plurality of construction machines that jointly perform construction work in each of the construction phases, namely construction phase 1, construction phase 2, and construction phase 3. In the 3D Gantt chart information 165, moreover, a work "schedule" is associated with each vehicle ID. The 3D Gantt  
25 chart information 165 also contains position data P indicating X-Y two-dimensional positions P(X, Y) at the construction site.

The server apparatus 11 comprises a theft notification system 191. The theft notification system 191 is a system that compares the work "schedule" for



"schedule" for, and whether or not actual work is being performed by, the follower machine 33 will disagree because maintenance was performed or a trouble was corrected with the "schedule" left unrevised.

That being so, whether or not a theft has occurred is next established by  
5 comparing the position P in the construction site where the follower machine 33 should be operating and the actual position.

The theft notification system 191 reads out the construction site position data P corresponding to the follower machine 33, based on the vehicle ID data 200a, from the 3D Gantt chart schedule and performance results database  
10 141A, and also detects the actual position of the follower machine 33 based on the vehicle position h that is part of the vehicle condition data 200b. As a result, if the construction site position P where the follower machine 33 should be operating and the actually detected position of the follower machine 33 are separated by a prescribed threshold value or more, it is judged that a theft has  
15 occurred and that the follower machine 33 has been removed from the construction site, whereupon theft information 179 is produced. Also, the date and hour that the judgment was made that a theft had occurred are recorded as the date and hour of the theft. The theft information 179 comprises data indicating a message to the effect that a theft has occurred, the vehicle ID data  
20 200a for the stolen construction machine, the construction site position data P for where the stolen construction machine should be operating, data indicating the date and hour it was stolen, and current detected position data for the stolen construction machine (step 802).

The theft information 179 are transmitted from the server apparatus 11  
25 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5 and stored in memory in the terminal device 31a.

Hence, as diagrammed in Fig. 9, on the display screen 301M of the monitor device 300 carried on board the leader work machine 31 are displayed the theft information 179, that is, a message that the follower machine 33 was stolen, the vehicle ID data 200a (P-33) of the stolen follower machine 33, the date and hour the machine was stolen, the construction site position data P for where the stolen follower machine 33 should be operating, and the current position of the stolen follower machine 33. The theft information 179 is emergency information, moreover, wherefore the display screen of the monitor device 300, irrespective of the content currently being displayed, will be forcibly switched to display the theft information 179. In that case, the display location 316 called "emergency screen display" indicated in Fig. 12 will flash, notifying the operator that this is an emergency screen.

The operator of the leader work machine 31 can promptly implement suitable measures himself or herself, such as contacting the proper people (such as the lease company 90a or the police station 92a), based on the theft information 179 displayed on the display screen 301M.

Also, the theft information 179 is transmitted from the server apparatus 11 directly to the terminal device 93a of the police station 92a, which constitutes the proper authorities, via a radio communication link 5, communication satellite 3, and radio communication link 5, and is stored in memory in the terminal device 93a. In that case, furthermore, the theft information 179 may be made a voice signal. Hence the police station 92a can promptly initiate an appropriate investigation based on the theft information 179.

Next, a case where the follower machine 33 in construction phase 1 has been involved in an overturn accident is supposed.

The vehicle condition data 200b consisting of the hydraulic pressure a, oil temperature b, water temperature c, stress d, engine r.p.m. e, lever control

input signals f, hour meter time elapsed g, vehicle position h, and vehicle inclination angle k are detected by the sensor group provided in the follower machine 33. Also, operator ID data 200c specifying the operator on board are associated with the follower machine 33. The vehicle condition data 200b  
5 detected in the follower machine 33, together with the vehicle ID data 200a and the operator ID data 200c, are transmitted via a radio communication link 6 to the leader work machine 31. These data are transmitted from the terminal device 31a of the leader work machine 31 to the server apparatus 11 via a radio communication link 5, communication satellite 3, and radio communication  
10 link 5.

When the vehicle ID data 200a for the follower machine 33 are transmitted to the server apparatus 11, the type "P" and model "model 2" corresponding to the vehicle ID data 200a (P-33) are read out from the machine type and model specific machine number database 160. It is assumed  
15 that the association of the machine number "33" to the model "model 2" has been made in the machine type and model specific machine number database 160.

Next, standard condition data corresponding to the type "P" and model "model 2" are read out from the machine specific standard condition data  
20 database 151. Next, the vehicle condition data 200b for the follower machine 33 and the read out standard condition data are compared, and a judgment as to whether the vehicle condition is normal or anomalous is made in the same manner as was described with reference to Fig. 17(a).

When, as a result thereof, the condition is "anomalous," further  
25 processing is then performed to determine whether or not the anomalous phenomenon constituted by an "overturned condition" has occurred.

Specifically, anomalous phenomenon data corresponding to the type "P" and model "model 2" are read out from the machine specific anomalous

phenomenon data database 152. Next, the read out anomalous phenomenon data are compared against the vehicle inclination angle  $k$  in the vehicle condition data 200b for the follower machine 33 to judge an "overturned condition." For example, in a case where "the vehicle inclination angle  $k$  continued to equal or exceed the threshold value for a prescribed time or longer," it will be judged that an "overturned condition" has been sustained, and overturn accident information 180 will be produced. The date and hour at which the judgment of that "overturned condition" was made will be recorded as the date and hour the accident occurred. The overturn accident information 180 comprises data indicating a message to the effect that an overturn accident has happened, vehicle ID data 200a for the construction machine involved in the overturn accident, the construction site position data  $P$  for where the construction machine involved in the overturn accident should be operating, data indicating the date and hour the overturn accident occurred, and the operator ID data 200c for the operator on board the construction machine involved in the overturn accident (step 803).

The overturn accident information 180 is transmitted from the server apparatus 11 to the terminal device 31a of the leader work machine 31 via a radio communication link 5, communication satellite 3, and radio communication link 5, and stored in memory in the terminal device 31a.

As diagrammed in Fig. 9, on the display screen 301N of the monitor device 300 carried on board the leader work machine 31 is displayed the overturn accident information 180, that is, a message that an overturn accident has occurred, the vehicle ID data 200a ( $P$ -33) for the follower machine 33 involved in the overturn accident, the date and hour the overturn accident occurred, the construction site position data  $P$  for where the follower machine 33 involved in the overturn accident should be operating, and the operator ID data 200c for the operator on board the follower machine 33 involved in the

overturn accident. The overturn accident information 180 is emergency information, moreover, wherefore the display screen of the monitor device 300, irrespective of the content currently being displayed, will be forcibly switched to display the overturn accident information 180. In this case, the display location 316 called "emergency screen display" indicated in Fig. 12 will flash,  
5 notifying the operator that this is an emergency screen.

The operator of the leader work machine 31 can promptly implement suitable measures himself or herself, such as contacting the proper people (such as the lease company 90a or the fire fighting (emergency) station 92b),  
10 based on the overturn accident information 180 displayed on the display screen 301N.

Also, overturn accident information 180 is transmitted from the server apparatus 11 directly to the terminal device 93b of the fire fighting (emergency) station 92b, which constitutes the proper authorities, via a radio communication link 5, communication satellite 3, and radio communication link 5, and is stored in memory in the terminal device 93b. In this case,  
15 furthermore, the overturn accident information 180 may be made a voice signal. Hence the fire fighting (emergency) station 92b can promptly initiate suitable emergency measures based on the overturn accident information 180.

The follower machine 33 is described representatively in the foregoing, but theft information 179 and overturn accident information 180 are also produced automatically, in the same manner, for the other follower machines 31, 33, 34, and 35, and for the leader work machine 31, whereupon appropriate measures can be taken promptly.  
20

Thus the operator of the leader work machine 31 can also fulfill the role of a general site manager in making notifications of thefts or overturn accidents. Theft information 179 and overturn accident information 180 are  
25

also produced automatically, in the same manner, in construction phase 2 and construction phase 3, whereupon appropriate measures can be taken promptly.

Based on this embodiment, as described in the foregoing, the operator of a leader work machine of a plurality of construction machines is able to fulfill the multiple roles of such managers as a service supervisor, general site foreman, general site manager, and office manager, without requiring other managers, wherefore work efficiency improves dramatically.

In this embodiment, furthermore, one construction machine out of a plurality of construction machines is made the leader work machine, but it is permissible to have two or more leader work machines.

In the embodiment described in the foregoing, it is assumed that the communication conditions for the radio communication link 5 with the communication satellite 3 are good.

However, when the communication conditions with the radio communication link 5 become poor, such work machine information as the vehicle ID data and vehicle condition data 200 cannot be transmitted from the leader work machine 31 to the server apparatus 11, and management information such as the revised 3D Gantt chart proposal information 166 and theft information 179 cannot be transmitted from the server apparatus 11 to the leader work machine 31. Hence such management information as the revised 3D Gantt chart proposal information 166 and theft information 179 can no longer be obtained at the leader work machine 31.

Thereupon, it becomes necessary to make provision so that, even when such communication failures occur, one's own vehicle 31 and the follower machines 32 to 35 can be managed during the time that communications are down, and so that management information can again be obtained smoothly at the point in time when communications are reopened.



In order to realize that, it is only necessary to provide, in the leader work machine 31, a judgment processing apparatus for judging whether communications are possible or impossible by the radio communication link 5 between the leader work machine 31 and the server apparatus 11.

5        There are two cases where communications are impossible, namely when a communication obstruction has developed due to the influence of an obstructing object, and when the communication terminal carried on board the communication satellite 3 or the leader work machine 31 has a trouble.

10        An object that obstructs communications, such as a mountain or building, exists between the communication satellite 3 and the leader work machine 31. Or, when the altitude of the communication satellite 3 is low (when the maximum angle of elevation is small), the obstruction to communication presented by the obstructing object becomes great and communication conditions become poor.

15        That being so, when the communication satellite 3 no longer responds to a call made by the leader work machine 31, it is judged that either the communication satellite 3 itself has failed, or that a communication obstruction has developed.

20        Or, by detecting currents flowing in the antenna of the leader work machine 31 or the like, a judgment is made that a trouble has occurred in one's own communication terminal.

25        When it is judged that communications by the radio communication link 5 are impossible, the latest management information received by the leader work machine 31 via the radio communication link 5, and the latest work machine information for the follower machines 32 to 35 and the latest work machine information for one's own vehicle 31 received by the leader work machine 31 via the radio communication links 6, are stored in memory provided in the leader work machine 31 until it is judged that communications

by the radio communication link 5 have again become possible. However, every time new work machine information is received by the leader work machine 31 via the radio communication links 6, and every time new work machine information is acquired for one's own vehicle 31, the content stored in memory is updated.

Thus, during the interval until communications by the radio communication link 5 are reopened, one's own vehicle 31 and the follower machines 32 to 35 can be managed based on the latest management information (such as the revised 3D Gantt chart proposal information 166) being stored and held. Then, when communications by the radio communication link 5 have been reopened, by transmitting the latest work machine information (vehicle ID data and vehicle condition data 200 and the like) being stored and held to the server apparatus 11, such management information as the revised 3D Gantt chart proposal information 166 can be produced by the server apparatus 11, and that management information can be acquired by the leader work machine 31.

With the embodiment described in the foregoing, moreover, it is assumed that data communications between the server apparatus 11 and the leader work machine 31 are conducted by the radio communication link 5 with the communication satellite 3. However, that communications scheme is only one example, and any communications scheme can be adopted. Specifically, existing ground waves may be used instead of a communication satellite. Or communications may be conducted using existing telephone lines. Or communications may be conducted via an existing portable ground station or PHS ground station.

In particular, it is conceivable that the construction machines 31 to 35 could perform work underground. In that case, obstacles to communications

would arise when conducting data communications with existing satellite communication equipment.

That being so, a relay station could be newly established for securing communications between the underground leader work machine 31 and the communication satellite 3 above, and data communications conducted via that relay station.

Embodiment is also possible wherewith the communication link between the server apparatus 11 and the leader work machine 31 is made redundant, with two or more links. By providing for communication link redundancy in such manner, the probability of communications being judged impossible can be made exceedingly small.

Nevertheless, in general, data communications between the leader work machine 31 and the server apparatus 11 are often conducted using satellite communication links, which involve high communication costs, because the distances involved are long, unlike with the reciprocal radio communications between the construction machines 31 to 35.

That being so, there is a need to build systems wherewith the communication costs between the leader work machine 31 and the server apparatus 11 can be kept low, and wherewith also data can be processed comprehensively at the server apparatus 11 end as with the embodiment described in the foregoing.

An embodiment is described next wherewith that is realized by imparting the functions of a server apparatus in the leader work machine 31.

Specifically, on the server apparatus 11 end, as in the embodiment described above, a database 100 is provided wherein are stored managing data (such as information on construction projects scheduled to be ordered 600a) for managing a plurality of construction machines 31 to 35, and management information production software (such as the construction project specific

optimized 3D Gantt chart production system 110) for producing management information (such as revised 3D Gantt chart proposal information 166) based on the managing data noted above and on work machine information (such as vehicle ID data and vehicle condition data 200).

5        Thereupon, when the leader work machine has been determined, as, for example, where the construction machine 31 is the leader work machine in construction phase 1, the server apparatus 11 transmits the managing data stored in the database 100, and the management information production software, to that newly determined leader work machine 31, via the radio  
10   communication link 5. After that, the leader work machine 31 functions as the server apparatus 11.

Work machine information is detected by sensors provided in the plurality of follower machines 32 to 35, as the work of the plurality of construction machines 31 to 35 progresses, and that detected work machine  
15   information is transmitted to the leader work machine 31 via a radio communication links 6.

The leader work machine 31 produces management information based on the work machine information that is transmitted to it from the plurality of follower machines 32 to 35 via the radio communication links 6, its own work  
20   machine information, and both the managing data and management information production software transmitted thereto from the server apparatus 11 via the radio communication link 5.

The leader work machine 31, based on that produced management information, manages that selfsame vehicle 31 and the follower machines 32 to  
25   35. Also, because it functions as the server apparatus 11, the leader work machine 31 updates the managing data by updating the information on construction projects scheduled to be ordered 600a if construction work is newly ordered, and such like, and transmits those updated managing data to the

server apparatus 11, via the radio communication link 5, every time a certain time period elapses.

Here, the transmission of the managing data is performed at an interval that, at the longest, is the interval of a single construction phase. Preferably, however, such transmission is made regularly at a prescribed time interval, such as once a day, once an hour, or once a minute.

At the server apparatus 11, the content stored in the database 100 is updated by the latest managing data transmitted.

Based on this embodiment, as described above, the radio communication link 5 with the communication satellite or the like is only used when the construction machine 31 has been determined as the leader work machine and the content stored in the database 100 is transmitted to that leader work machine 31, and when the managing data are transmitted to the server apparatus 11 every time a certain period elapses (such as every construction phase, every day, every hour, or every minute). For that reason, the communication costs for the radio communication link 5 with the communication satellite or the like are dramatically reduced.

The content stored in the database 100 of the server apparatus 11, furthermore, are continually updated by the latest managing data, and, in like manner as with the embodiment described earlier, data can be comprehensively managed at the server apparatus 11 end.

An embodiment is described next which does not require the radio communication link 5.

Specifically, in this case, on the server apparatus 11 end, as in the embodiment described above, a database 100 is provided wherein are stored managing data (such as information on construction projects scheduled to be ordered 600a) for managing a plurality of construction machines 31 to 35, and management information production software (such as the construction project

specific optimized 3D Gantt chart production system 110) for producing management information (such as revised 3D Gantt chart proposal information 166) based on the managing data noted above and on work machine information (such as vehicle ID data and vehicle condition data 200).

5        Thereupon, when the leader work machine is determined, as, for example, when the construction machine 31 is the leader work machine in construction phase 1, the managing data stored in the database 100 of the server apparatus 11 and the management information production software will be written to a memory device in that newly determined leader work machine 10 31 by installing a portable recording medium such as a memory card.

Alternatively, provision may be made so that, instead of a recording medium being installed, the data and software are written directly to the memory device in the leader work machine 31 by input means such as a keyboard. After that, the leader work machine 31 functions as the server apparatus 11.

15        Work machine information is detected by sensors provided in the plurality of follower machines 32 to 35, as the work of the plurality of construction machines 31 to 35 progresses, and that detected work machine information is transmitted to the leader work machine 31 via a radio communication links 6.

20        The leader work machine 31 produces management information based on the work machine information that is transmitted to it from the plurality of follower machines 32 to 35 via the radio communication links 6, its own work machine information, and both the managing data and management data production software written to memory as described above.

25        The leader work machine 31, based on that produced management information, manages that selfsame vehicle 31 and the follower machines 32 to 35. Also, because it functions as the server apparatus 11, the leader work machine 31 updates the managing data by updating the information on

construction projects scheduled to be ordered 600a if construction work is newly ordered, and such like, and transmits those updated managing data to the server apparatus 11, via the radio communication link 5, every time a certain time period elapses.

5        Here, the transmission of the managing data is performed at an interval that, at the longest, is the interval of a single construction phase. Preferably, however, such transmission is made regularly at a prescribed time interval, such as once a day, once an hour, or once a minute.

10       Those latest updated managing data are written to the database 100 of the server apparatus 11, and the content stored in the database 100 of the server apparatus 11 are overwritten.

15       Based on this embodiment, as described above, unlike the embodiment described earlier, communications by a radio communication link 5 with a communication satellite or the like is made unnecessary, and communications only by radio communication links 6 such as local SS communications or the like are sufficient, wherefore communication costs are dramatically reduced.

20       The content stored in the database 100 of the server apparatus 11, furthermore, is continually updated by the latest managing data, and, in like manner as with the embodiment described earlier, data can be comprehensively managed at the server apparatus 11 end.

25       With these embodiments, furthermore, application to construction machines that perform work at a construction site is presumed, but application may be made to any type of work machine so long as a plurality of those work machines are jointly performing work. The present invention can be applied in cases where, for example, a plurality of ordinary automobiles are jointly engaged in work.